BELL TELEPHONE QUARTERLY

VOL. XIX OCTOBER, 1940 NO. 4

THE BELL SYSTEM'S PART IN NATIONAL DEFENSE
A STATEMENT BY PRESIDENT GIFFORD

OUTWITTING OPEN WIRE'S WORST FOE

AT THE CUSTOMER'S SERVICE

TESTING AMERICA'S EARS

FINAL STEPS IN SUPPLY DISTRIBUTION

THE CONQUEST OF A CONTINENT

AMERICAN TELEPHONE & TELEGRAPH CO. • NEW YORK

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Walter S. Gifford, President, American Telephone and Telegraph Company

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Walter S. Gifford

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This Bell System advertisement is current in national magazines during October

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BELL TELEPHONE QUARTERLY

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A Medium of Suggestion and a Record of Progress

VOL. XIX OCTOBER, 1940 NO. 4

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THE BELL SYSTEM'S PART IN NATIONAL DEFENSE

A Statement Broadcast over a Nation-wide Radio Network on October 14, 1940

By WALTER S. GIFFORD

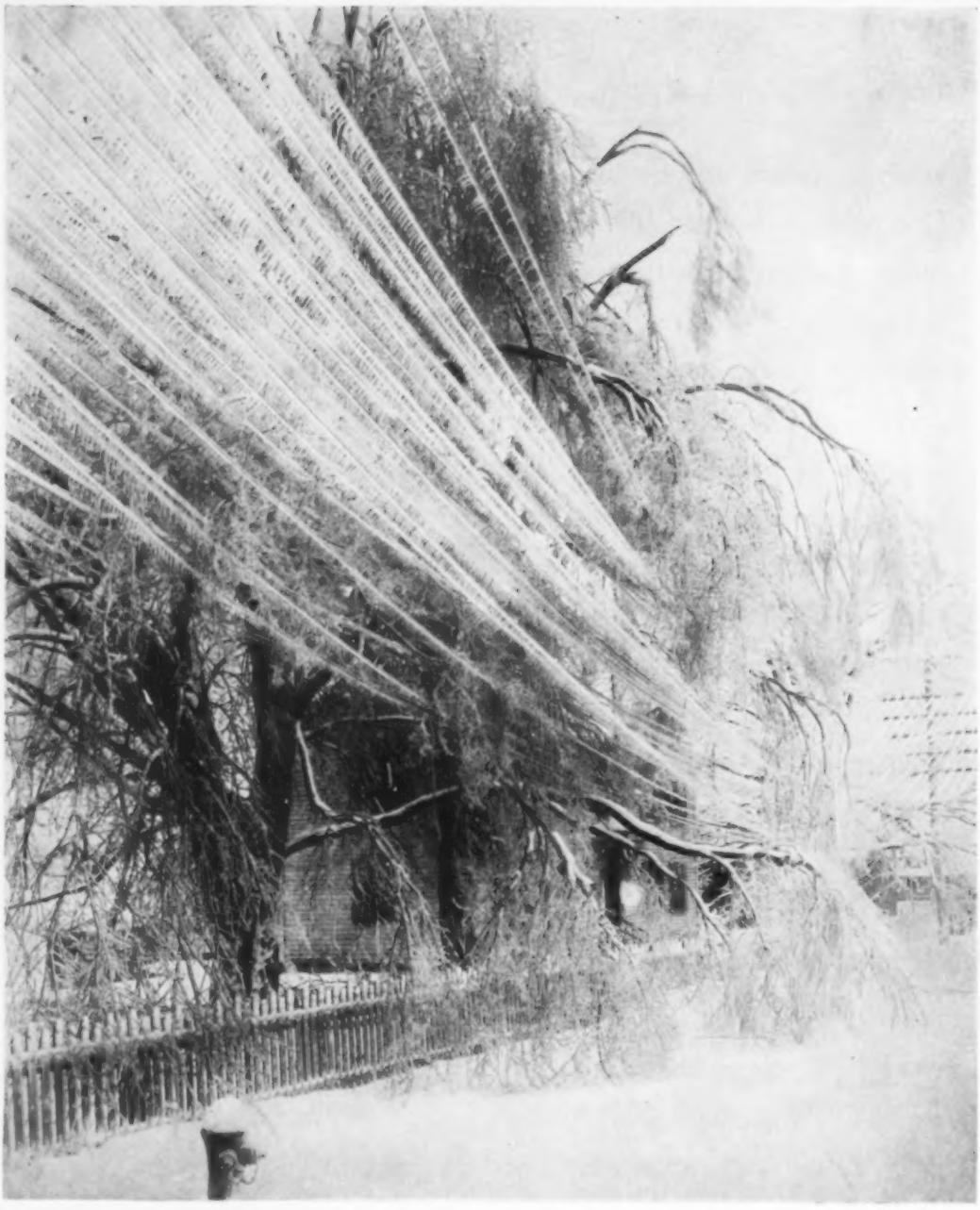
President, American Telephone and Telegraph Company

IN these critical times, national defense is the concern of all of us. Communications are an essential part of our national defense and I am happy to report to you that telephone facilities in America are by far the most comprehensive and the best in the world. In fact, surveying American industry as a whole, it is encouraging to realize — notwithstanding views to the contrary — that there is greater efficiency under American democracy than under any other form of government.

Your telephone service is the result of initiative and ability, fostered and given free rein in an enterprise privately owned and privately managed. And today we of the Bell System—and there are more than 300,000 of us—are

ready to do our full part in the national defense program. Our business is financially sound. We have the best telephone equipment in the world and we have plenty of it. It has been provided out of the voluntary savings of many hundreds of thousands of men and women. We have a great scientific laboratory, which constantly strives to improve the communication art in which we have always been the leader. Our Western Electric Company, manufacturer of telephone equipment for over sixty years, is our service of supply, with stocks of apparatus and materials in warehouses strategically located throughout the nation. The Laboratories and the Western Electric, with their scientific and manufacturing experience, are coöperating with the Army and the Navy and the air forces, and are helpful in supplying some of their important needs and in solving some of their important problems. Our telephone construction and maintenance crews are fully mechanized and can be concentrated anywhere quickly. Above all, trained and experienced men and women and the management work together in full coöperation, and we are accustomed to plan ahead so that the right material and the right skill will be at the right place at the right time.

It is a real satisfaction to all of us in the Bell System, and I feel sure it is to you, to know that we can contribute much to the success of our country's national defense — a success which will demonstrate anew the efficiency of American democracy.



NEW ENGLAND WINTER

This scene of ice-festooned telephone wires is Fig. 1 of the article which begins on the opposite page

OUTWITTING OPEN WIRE'S WORST FOE

Study of Areas Where Ice Storms Are Likely to Occur, Building to Withstand Expected Loads, Substitution of Cable as Economics Permit, Increase the Reliability of Outside Plant

By RAYMOND C. SILVERS

THE beauty of an ice-sheathed countryside glistening in the sun has long been a source of poetic inspiration. Countless schoolboys have declaimed from James Russell Lowell's "The Vision of Sir Launfal" that, "No mortal builder's most rare device could match this winter palace of ice." In fact, the sight of trees and bushes and blades of grass encased in brilliant icy armor is a cherished picture to nearly everyone.

But not to the telephone man. To him an ice storm means trouble.

To provide a service free from interruption is the constant aim of the telephone Plant design, construction, and maintenance forces. Wind and storm and flood—the elements—are among their strongest opponents. Tornado, fire, ice, torrential rains—one or more of these may strike anywhere and leave wreckage in its trail. Each year, however, the Bell System is building up greater resistance to them and thereby is continually increasing the reliability of its service. Research work in the Bell Telephone Laboratories leads to new materials and apparatus which make for this end. Stronger materials, closer manufacturing controls, new maintenance methods, the extension of the cable network—all these measures combine to make the outside plant more nearly invulnerable and bring it closer to that elusive goal of day-in and day-out uninterrupted service.

Through the years, in fact from its very beginnings, the Bell System has striven to build lines which would withstand the compelling grip of ice wherever ice storms might be expected; to build lines which would give service when ice has brought highway traffic to a standstill, immobilized whole communities, and put a special value on telephone communication. Each year sees telephone service more nearly proof against the sudden onslaught of these storms. The degree of success in this long-drawn battle against ice and its ally, wind, has been far greater than the casual observer may realize. Failures occur, yes; but it must be remembered that it is the failures which make victories go unsung.

Some of the problems that are met and some of the measures which have

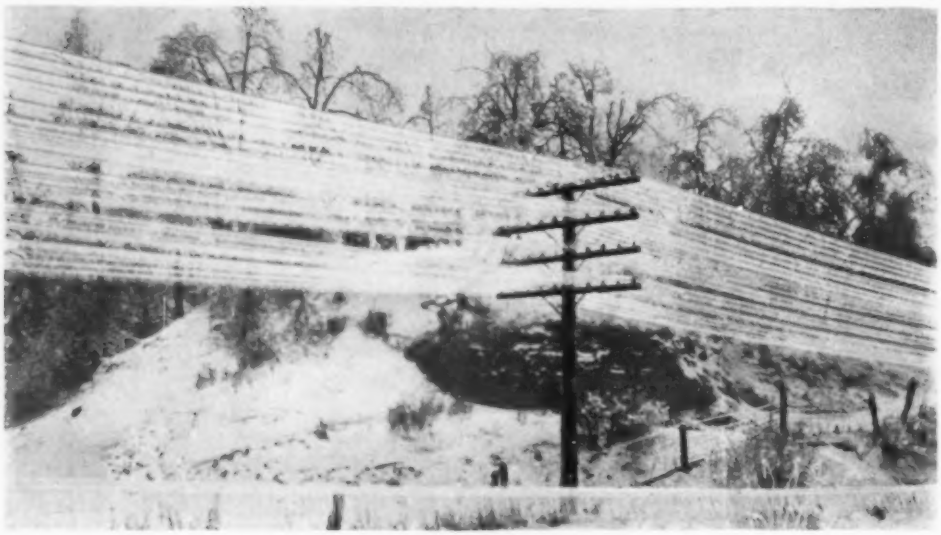


FIG. 2. IN WISCONSIN

brought about this greater dependability of Bell System service under winter conditions are discussed in this article.

When Ice Forms

As far as telephone plant is concerned, damage from ice is most likely to occur as a result of its formation about aerial wires during a rainfall when temperatures are either at or just below freezing. Less frequently, wet snow will accumulate in considerable amount on wires and poles; and in other cases atmospheric conditions may produce deposits of frost. In some parts of the Pacific Northwest, where occur what are locally known as "silver thaws," heavy encasements of rime have accumulated on wires to the thickness of several inches. Examples of accumulations of ice on wires and trees are shown in the accompanying photographs. Figure 1 (page 230) is a scene in New England; Figure 2 shows the ice covered wires of a line in Wisconsin; and the picture in Figure 3, taken in northern California, is an illustration of the extent to which insulators and crossarms become loaded and festooned with snow. Figure 4 is a photograph of ice and frost on a rural telephone line not far from Seattle. Measurements at this point showed the wire to be encased with ice to a diameter of ½-inch with a frost deposit overlaying the ice—the total diameter of wire, ice, and frost being 7 inches.

In 1911 Theodore N. Vail, then President of the American Telephone and Telegraph Company, wrote to J. J. Carty, the chief engineer, "I would like to have you prepare a map of the United States showing the extent and range of each sleet storm that we have had in this country which has affected the wires, going back as far as there are any particular records,

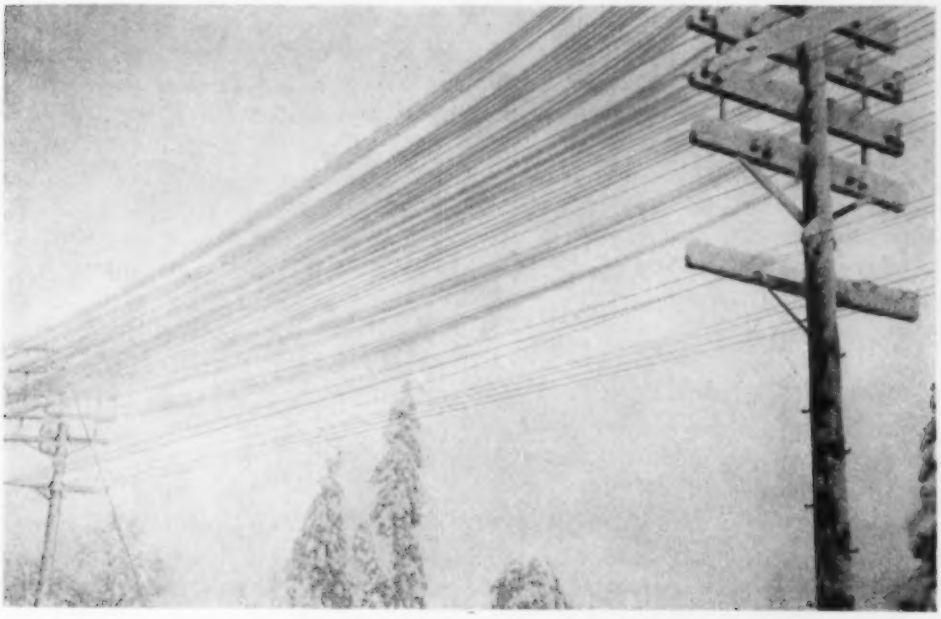


FIG. 3. IN THE MOUNTAINS OF NORTHERN CALIFORNIA

and far enough if possible to see whether any particular section of the country is more liable to these destructive sleet storms than others—the object being, if there are sections in the country where these storms are more liable to occur than others, that we can lay out our underground con-

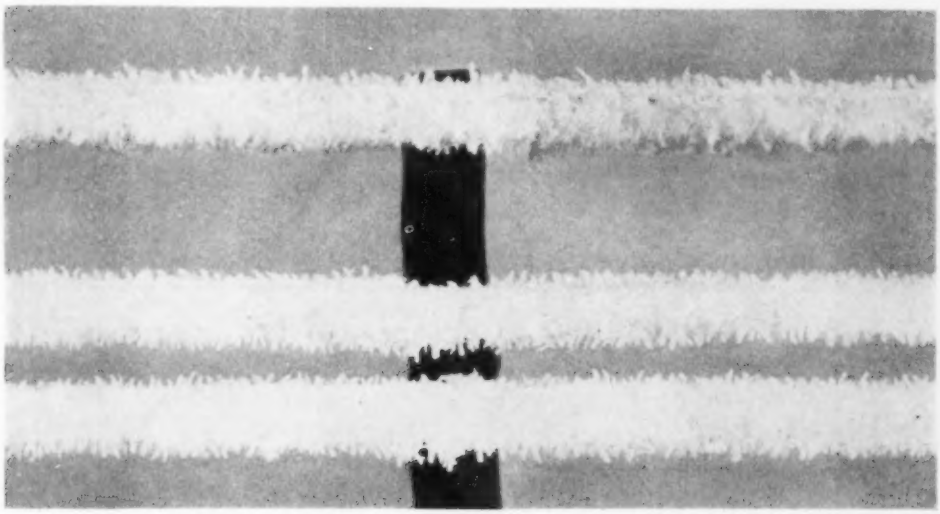


FIG. 4. ICE AND FROST

The total diameter of these encrusted telephone wires is seven inches

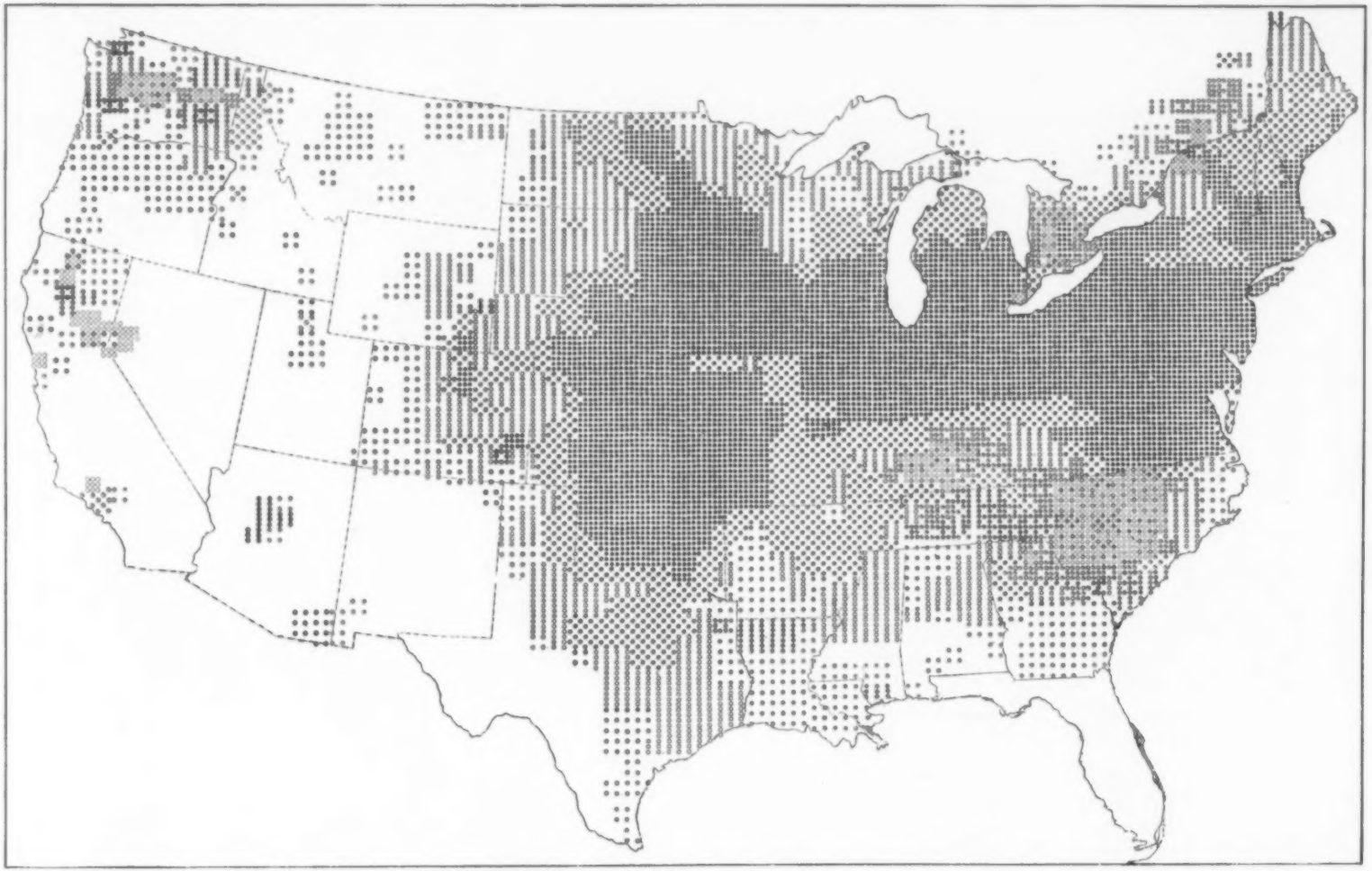


FIG. 5. ICE-STORM MAP

Pins with vari-coded heads record the incidence of ice storms in the United States during a period of more than a quarter-century. For the story which the different codes tell, refer to the opposite page

struction in such a way as to cover these sections first." After collecting all available information on ice storms affecting the Bell System plant prior to that time, the map was prepared for Mr. Vail.

This marked the start of the systematic compilation of detailed records of ice storm damage to System lines, including comprehensive data with regard to the severity of ice storms, their frequency and distribution, as the basis for intelligent design of the pole line and wire plant. From that time on, as storm data became available, they were posted, using coded-head pins, on a large wall map of which Figure 5 is a reproduction. This ice storm map covered the United States and that portion of Canada in which the Bell Telephone Company of Canada operates. The various Companies in the System continued to prepare these careful reports, which in turn were posted on the map until it represented the history of 25 years of experience with ice on wires of the Bell System.

For the purpose of the map, ice storms were divided into two classes from the standpoint of intensity: heavy and medium. When the diameter of the ice-covered wires in any storm was ¾-inch or greater, or when the damage was commensurate with a storm of this intensity, the storm was designated as "heavy." When the diameter in a given storm was less than ¾-inch but sufficient to cause appreciable damage to the aerial plant, it was regarded as "medium." It should be noted at this point that the above classifications of storms as "heavy" or "medium," made for the purpose of measuring storm severity and frequency, are not the same as the definitions of heavy and medium storm loading which were subsequently adopted in the National Electrical Safety Code, as discussed later in this article.

AREAS on the map (Figure 5) in which "heavy" ice storms were recorded are marked with pins with heads having a black background. The pin head code for showing the frequency of occurrence of such heavy storms is indicated at the bottom of this page. Areas in which medium ice storms only were experienced are designated by pins having a white background with black markings, the same general type of code as in the case of heavy storms being employed but using black instead of white lines, crosses and dots to indicate frequency of occurrence.

PIN HEAD CODE FOR HEAVY STORMS

See map on opposite page

Average Occurrence of Heavy Storms	Coded
At least once in 3 years	Solid black
Once in every 3–6 years	Black with white stripe
Less than once in 6 years	Black with white cross
Only one heavy ice storm	Black with white spot

which the different codes tell, refer to the opposite page

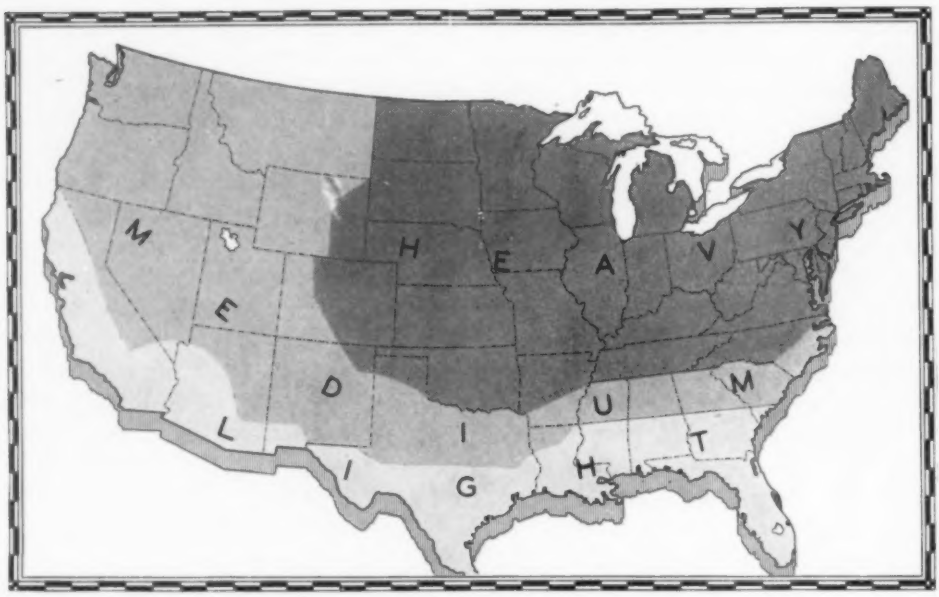


FIG. 6. N.E.S.C. STORM LOADING MAP

Since 1926 this has served as a guide to the wire-using companies

Again, to keep clear the distinction between storm loading and storm damage, this map indicates only the intensity and frequency of occurrence of storm loads. As indicated later, in the design and maintenance of the telephone plant the strength of construction and use of the more storm proof types of plant are varied to meet the storm loads which experience shows may be imposed. A map such as that shown in Figure 5 serves its main purpose when it shows which areas should be fortified against damage and service disruption.

IN those areas where heavy storms predominated, the occurrence of medium storms has not been indicated. However, in sections where most storms were "medium," but in which some heavy storms occurred, pins with black background and pins with white background are to be seen intermingled.

The method adopted in posting the map results in a closer spacing of the pins in those areas in which ice storms are more prevalent. In those areas where the telephone plant was not operated by companies associated in the Bell System, in which no open-wire telephone plant existed, or in which no ice storms were reported, no pins were placed. It is interesting to observe over what an extensive portion of the United States at least one ice storm was experienced during the period of the study.

Data such as this map provided were not available from any of the regular sources of meteorological information, and were needed to put on a more exact and economically sound

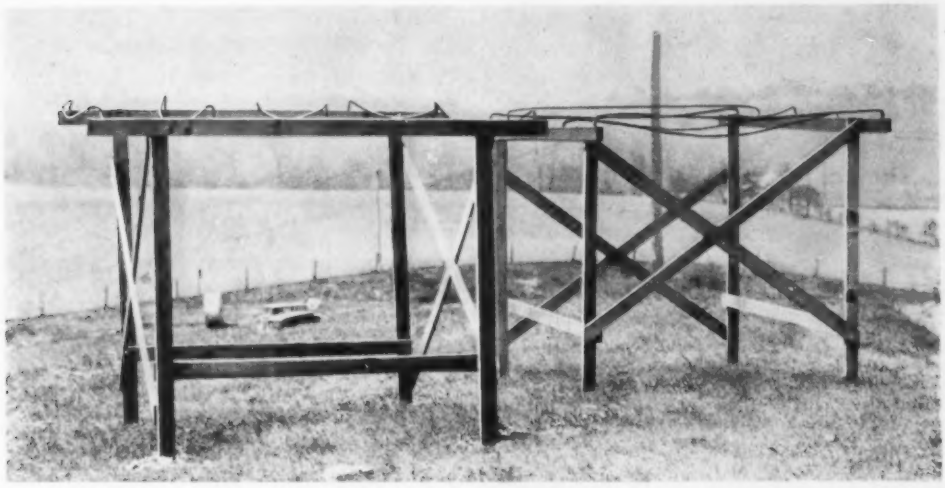


FIG. 7. ICE CATCHERS

These racks of various sizes of wire, located at different points throughout the country, add to the information about accumulations of ice

basis the determination of the type of telephone line adequate for a given locality. The importance of delineating these ice storm zones is evident when we consider that the cost of, say, a typical 30-foot 40-wire pole line constructed to meet conditions to be expected in areas where heavy ice storms occur frequently would be one third again as much as would that of a similar line where such storms do not occur.

The N.E.S.C. Code

IN the National Electrical Safety Code, drawn up under the procedure of the American Standards Association by a sectional committee under the sponsorship of the National Bureau of Standards, the United States is divided into three different storm loading areas based on weather conditions, as shown in Figure 6. The establishment of these areas as a guide to the wire-using companies in their basic construction and maintenance practices has been an important contribution to the art of overhead line construction and has made for safety to employees and the public as well as being an aid in setting up standards to promote continuity of service. The data on ice storms compiled by the Bell System, previously referred to, have been helpful in this connection.

Since the issuance of the fourth edition of the Safety Code in 1926, additional data on ice and wind during storms have been accumulated by the electric light and power, railroad, telegraph, and telephone companies, all of which coöperate in the preparation of the Code. Data on wind velocities were, in the main, obtained from the United States Weather Bureau. In addition to collecting data on ice deposits on line wires and on the wind conditions accompanying ice accretions, racks carrying lengths of different sizes of wire were placed at various locations throughout the country as an aid in determining the magni-

FIG. 8. SUBSTITUTE FOR ICE

Since it is not always winter at the Chester, N. J., field laboratory of the Bell Telephone Laboratories, bricks are here being hung on wires to test their strength

tude of ice accumulations. Figure 7 shows such racks installed in 1929 at the Chester, New Jersey, field laboratory of the Bell Telephone Laboratories. These are only two out of more than 100 located at various points throughout the country by a joint communications and railroad committee to study storm loading conditions, the work being done by the Association of American Railroads, Western Union Telegraph Company, Postal Telegraph Company, and Bell System coöperatively. Similar work was done under the auspices of the Edison Electric Institute, involving the installation of approximately 125 racks and associated equipment for taking observations on all formations on electrical supply line conductors.

In the light of additional storm data which have been collected, it appears that in the revision of the Code, which is now under way, some changes may be desirable in the general lines of demarcation between the areas and in the assumed wind velocities in these areas.

Ice Loads and Telephone Wires

OUR early arithmetic taught us that the area of a circle is in proportion to the square of its radius. From this, it follows that the weight of ice accumulations on wires increases rapidly with the thickness of the coating. A sheath of ice of ¼ inch in radial thickness adds a load of only two ounces per foot of wire. A ½-inch coating, however, results in the addition of a weight of about six ounces per foot, and an accumulation of 1 inch in radial thickness amounts to about 22 ounces per foot. By simple arithmetic, the weight of a 1-inch coating of ice on a telephone wire in a 150-foot span would amount to about 200 pounds, or about 15 to 40 times the weight of the wire itself. This is evidence of the potentialities for damage through ice loads alone.

It must not be inferred that ice is necessarily deposited as uniform and symmetrical coatings. On the contrary, it may be said that, except in the case of light glazes, a uniform ice coating is found only infrequently. The fact that it ordinarily appears as a pendant deposit of non-circular section, and frequently in the form of

icicles, is only one factor which has added to the difficulties of obtaining reliable and useful data on ice accumulations and appraising their effect. To place on a workable basis information obtained in the field on ice deposits, it has been the practice to equate it into terms of equivalent radial ice coatings.

In laboratory tests it is often necessary to simulate ice loads. Figure 8 shows a span of wire at the Chester field laboratory being loaded with bricks to test a new type of tie for securing the wire at the insulators.

IT is not alone the weight of ice on a wire which makes for damage. Its presence also increases the sail area which the wire presents to the wind. The diameters of line wires commonly used in telephone work vary from about .080 inch to about .165 inch and it is readily evident that a ½-inch radial ice coating increases the area exposed to the wind by 700 to 1300 per cent. With a sufficiently strong wind transverse to the line, the wind pressure per foot of ice-covered wire may considerably exceed the weight of wire and ice combined. For this reason a heavy ice load acting together with a strong wind results in a particularly destructive combination.

Moderate ice loads alone have little mechanical effect on telephone wire. But fairly light glazes of ice when acted upon by wind of only medium intensity sometimes are responsible for a phenomenon known as dancing, which is now being given active study on wires and cables both in service and at the Bell Telephone Laboratories' testing ground at Chester.

FIG. 9. CROSS-ARMS DOWN
The weight of the ice load on these wires has pulled the cross-arms from the pole

Dancing wires oscillate in a plane vertical to the wind. The dancing is sometimes of sufficient violence to short-circuit the wires; to cause mechanical damage at the insulators, due to chafing; or to produce breakage or weakening of the wire from the "fatigue" of the metal which results when the wires are bent back and forth while dancing. Some types of long distance carrier telephone circuits must be built with relatively close spacing between the two wires constituting each pair, and on such circuits the swinging of ice-glazed wires in the wind may result in the actual freezing together of the wires.

Heavy ice loads or combinations of ice and wind may result in either wire breaks due to the increased tensions developed or in permanent stretching of the wire. Increased sags due to permanent stretching not only reduce clearances between wire and ground but also increase the possibility that the wires may swing together in the wind during and also after the ice storm. A severe ice storm may therefore not only necessitate the replacement or repair of broken or damaged wire but may entail considerable work and expense for the readjustment and correction of wire sags.

ICE accumulations which may not be sufficient to cause mechanical damage may react adversely on the transmission efficiency of telephone circuits. At carrier frequencies they may greatly increase the attenuation losses during their presence on the wires. In combination with an accumulation of ice on crossarms, insulators, and at transposition points—where wires interchange positions in order to minimize interaction between circuits and improve circuit performance—these losses may reach a point where the circuits become temporarily inoperative.

On the most exacting types of long distance circuits, it is essential that uniformity of wire sags be maintained within close limits in order to avoid crosstalk. Permanent stretching of wire may take place in varying degrees under heavy storm loads, with the result that after the ice has melted there may be considerable differences in the sags between the two wires of a pair making up a telephone circuit. To prevent the tendency, under such conditions of unequal wire sag, for one telephone circuit to crosstalk over into another, it may be necessary following a storm to make a general readjustment of sags to meet the limits permissible for sag differences.

Effects of Ice and Wind Loads on the Pole Structure

WHILE wire is the chief sufferer, ice sometimes builds up to the point that the crossarms can no longer support the weight of the ice-covered wires. Then the arms either break or are stripped from the pole. Figure 9 is a photograph taken after a New England ice storm which tore the crossarms from their attachments to the pole. Crossarms and poles may also fail due to unbalanced loads on the pole structure resulting from breakage of the wire by excessive ice loads.

The most serious condition, however, from the standpoint of the pole plant, occurs where a strong wind transverse to the line either accompanies the formation of ice and snow deposits or follows a storm before the ice accumulation has had an opportunity to melt. A pole break due to such conditions is shown in Figure 10. It is fortunate, however, that while ice storms may occur fairly frequently and high winds still oftener, the chances of heavy ice and high wind occurring simultaneously are fairly remote.

To investigate the effects of wind on wires, considerable use is made of the wind tunnel, where conditions approximating those encountered in actual practice can be produced at will. Tests made both in the wind tunnel and under natural conditions have demonstrated the interesting fact that

FIG. 10. POLE DOWN

This pole has succumbed to the combined forces of ice-weight and wind

when a line carries a number of ice coated wires, some of the wires offer an appreciable amount of wind shielding to other wires on the line. In areas where ice is a factor, and in those cases where the poles carry a sufficiently large group of wires to furnish effective shielding, allowance is made for such shielding in the amount of strength provided in the pole structure. It might be noted in this connection that while the effect of shielding on a group of wires is such, in the aggregate, that recognition can be given it in the pole design, no account can ordinarily be taken of it in considering the effects of wind and ice on individual wires.

IT is an entirely practicable matter to design both the wire and pole plant to withstand specified amounts of ice and wind, but it is not feasible, except in a general way, to design against the widely variable loads and conditions imposed by trees broken or uprooted by ice and wind. The wire plant is particularly vulnerable to damage by ice-laden trees, and a great deal of the subscriber distribution plant is unavoidably exposed to possible tree damage. An example of this type of trouble is shown in Figure 11. The insulated wire which forms the subscriber's service connection from pole to house, and which often must thread its way between the trees on side-walk and lawn, is particularly subject to damage of this type.

As an example, in one severe ice storm which affected certain areas in southern New England, New York, and New Jersey during the past winter, fully 90 per cent of the interruptions to subscribers' service were due to trees or the branches of trees

FIG. 11. TREE BREAK

Where wires may support the weight of ice alone, the added burden of tree limbs sometimes brings them down

falling across the insulated wire connecting the subscriber's premises with the telephone system. Relatively few breaks occurred in these service connections other than those caused by trees. Although on account of its strength bronze wire is used for the house connection and the policy is followed of avoiding trees as far as practicable, it is inevitable that some damage to aerial house connections should occur at these times. In order to insure against interruption of service from such causes, the Telephone Company and the individual subscriber frequently coöperate to place the house connection underground.

Coping With Ice Loads

NEEDLESS to say, to provide economically against damage and service interruptions due to ice and wind requires an intimate knowledge of the conditions which must be met. The severity and frequency of storms may vary widely between adjoining areas. The direction of the line with respect to the winds which prevail at the time of ice storms is also important, as is the effect of wind breaks offered by hills and woods. Finally there is the question of how great an expenditure for extra strength can be justified from a service insurance standpoint; a transcontinental circuit, for exam-

FIG. 12. H FIXTURES

Construction on the Argentine Pass, in the Rocky Mountains, to withstand unusual stresses

ple, justifies greater strength than an exchange circuit only half a mile long.

First thought must be given to the wires themselves. In the Bell System, hard-drawn copper and galvanized steel wire are the types used chiefly for open wire circuits. Size for size, steel wire is stronger than copper and is better mechanically than copper in other ways; but copper wire, having a much lower electrical resistance per unit of length, has important advantages from the standpoints of both voice transmission and the transmission of the necessary signals between the central office and subscriber or between central offices. Under many conditions, however, galvanized steel wire is a highly satisfactory material for open wire construction, particularly in exchange and rural lines. This is particularly true now that galvanized wire can be obtained with various weights of galvanizing designed to meet different degrees of corrosion to which it may be exposed in service in different localities.

Hard-drawn copper wire in the Bell System is, generally speaking, confined to four standard sizes having diameters of .080, .104, .128 and .165 inches, respectively, and with the breaking strengths ranging from 330 pounds for the .080 wire to 1325 pounds for the .165 wire. For the country as a whole, the .104 size is the most commonly used, .080 being limited largely to areas where ice is not a particular factor and the .128 or .165 size being used in toll circuits where greater insurance against the breaking and stretching of wire is desired.

IN Figure 12 are shown so-called H fixtures on the eastern slope of Argentine Pass in the Rocky Mountains in Colorado, on which all the wires are of

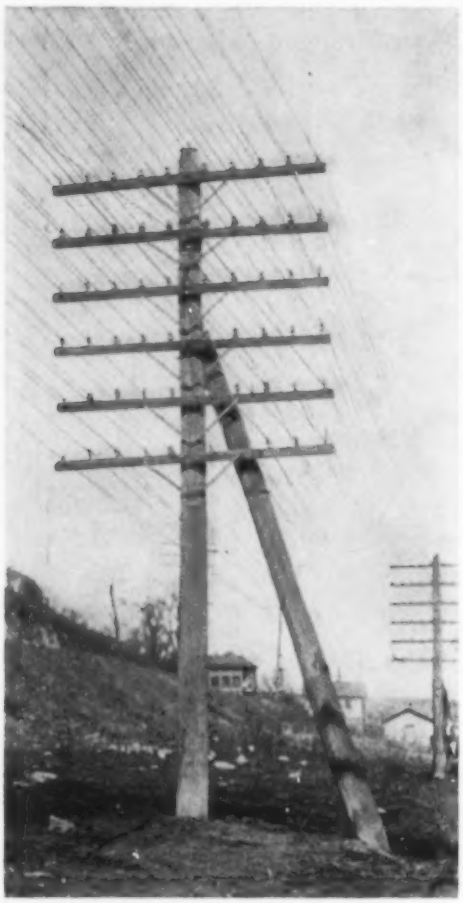


FIG. 13. PUSH-PULL BRACE
This type of construction gives added strength to a pole where needed

the .165 size and on which, on account of the extremely severe conditions, short spacing between the poles is used as well. For a short distance where this line crosses the topmost portion of the continental divide, the line strength is still further increased by substituting for each of the .165 copper wires a stranded galvanized steel cable having a breaking strength of 4000 pounds. In the sections where the steel strand is used, sections of poles are bolted across the tops of the fixtures to carry the wires instead of the sawed crossarms shown in Figure 12.

Some use has been made of bronze or other types of higher-strength wire where necessary to meet special conditions. The familiar rubber-covered wire used to make service connections to subscriber's premises is bronze, because its greater strength permits a smaller wire to be employed than otherwise, which is desirable from an appearance standpoint. Bronze has a higher electrical resistance than copper, but this is not important here since the length used is relatively short.

Naturally, the length of span with which a line is constructed affects the loads on both the line wire and on the poles. In the highest grade toll lines, where the maximum insurance is essential against breakage and stretching of the copper wire, span lengths are generally limited to about 130 feet. On lines carrying circuits of a less critical character, longer spans may be used after giving due weight to the service conditions, exposure to storms, strength of wire used, size of poles, and possible effects on maintenance. In rural lines employing high strength steel wire which has a breaking strength in excess of 1200 pounds, span lengths of 350 feet in heavy storm areas and 450 feet in medium storm areas are commonly used.

IN building and maintaining lines, it is standard practice in the Bell System to use poles of a diameter and strength which are in keeping with the particular storm exposures concerned,

the wire load carried, and the character of the facilities on the line. Also, corresponding adequate minimum strength standards have been established for poles in service; and to ensure the maintenance of strength in excess of these minimum values, systematic recurring inspections are made of poles in plant. Poles which are found on these routine inspections to be approaching these minimum strength standards as the result of mechanical damage or deterioration through insect attack or decay are either replaced or strengthened. By thus watching carefully both the strength new and the replacement strength of the pole lines, breakage of poles due to storms is minimized. A record kept over 15 years and embracing many millions of poles throughout the Bell System shows that the yearly breakage due to ice storms amounts to only a small fraction of one per cent of poles in service. Of this extremely small percentage, many were casualties of falling trees. In fact, if storms were the sole cause of pole failures in the Bell System, the average pole would last 300 years or more.

It might be mentioned here that a large percentage of the poles included in this study had not been treated with a timber preservative prior to installation and, therefore, some were poles which had suffered some loss of strength due to decay but still possessed strength in excess of the replacement standards. Since all but a small percentage of the poles currently being used in the Bell System are treated with preservative before installation, and since the resistance of treated timber to decay greatly increases its reliability in service, breakage due to storms will be reduced to even lower values.

FIG. 14. AERIAL CABLE

With many wires enclosed in a lead sheath, aerial toll cable is largely immune to damage from ice and wind

WITH recurring inspections of poles in service usually made at intervals of three to six years, depending on the reliability of the pole timber and whether or not it has been given a preservative treatment, the opportunity is afforded to single out the occasional deteriorated pole for replacement or repair. Thus the strength of the line as a whole is maintained at levels well above the

minimum for individual poles. As a matter of fact, new poles as installed ordinarily provide a degree of strength materially above the minimum required of such new poles, and it follows, therefore, that many lines have a strength at all times appreciably in excess of the minimum strengths required of new lines.

It is axiomatic that good engineering requires proper consideration of economic as well as mechanical principles. It is obvious that a plant so designed that no pole would ever be broken in the course of a storm would both be wasteful of our timber resources and result in unnecessary and perhaps prohibitive cost to the user of telephone service. There must be a balance between strength and the cost of the insurance which extra strength provides, and this point of balance can only be established through experience combined with engineering judgment. While it is eminently proper that there should be general minimum strength standards for the pole plant, based on the best possible data accumulated in regard to the extent, severity, and frequency of ice storms, the existence of such data and standards cannot be considered as a substitute for an intimate knowledge of the particular local conditions which must be met on any particular line or section of line.

Accordingly, in the Bell System, while there are generally accepted and very definite minimum strength standards, the engineers responsible for the construction and maintenance in local areas must determine to what extent these minimum standards should be raised to meet any particular conditions which may be encountered in their areas. For example, a river valley for a limited distance away from the river may be subject to heavy ice and frost accumulation, a line through a flat treeless area may be particularly exposed to wind as well as ice, or additional insurance may be desirable for a line whose failure would result in serious service interruptions because of the outstanding importance of the line.

Additional strength may be provided by various means, such as stronger poles or wire, heavier crossarms, shorter spans, stouter guying, and by pole fixtures of various types. One type of strengthening fixture is the H fixture shown in Figure 12. Another is the push-pull brace, Figure 13.

The Bell System Cable Network

EACH aerial wire on a line picks up its own quota of ice, and when this is multiplied by 30 or 40 wires, there is considerable sail area exposed to the wind by the whole line. On the other hand, where the number of circuits warrants, several hundred or even thousand wires may be gathered together under a common lead sheath forming a cable of less than three inches in diameter. Such a cable, when it has accumulated a heavy ice coating, will present no more area to the wind than half a dozen similarly coated open wires. Moreover, in order to provide large strength margins to permit aerial cables to support safely the weight of men employed in their construction and maintenance, it is the practice to support aerial cables on stranded steel "messengers," some of which have breaking strengths

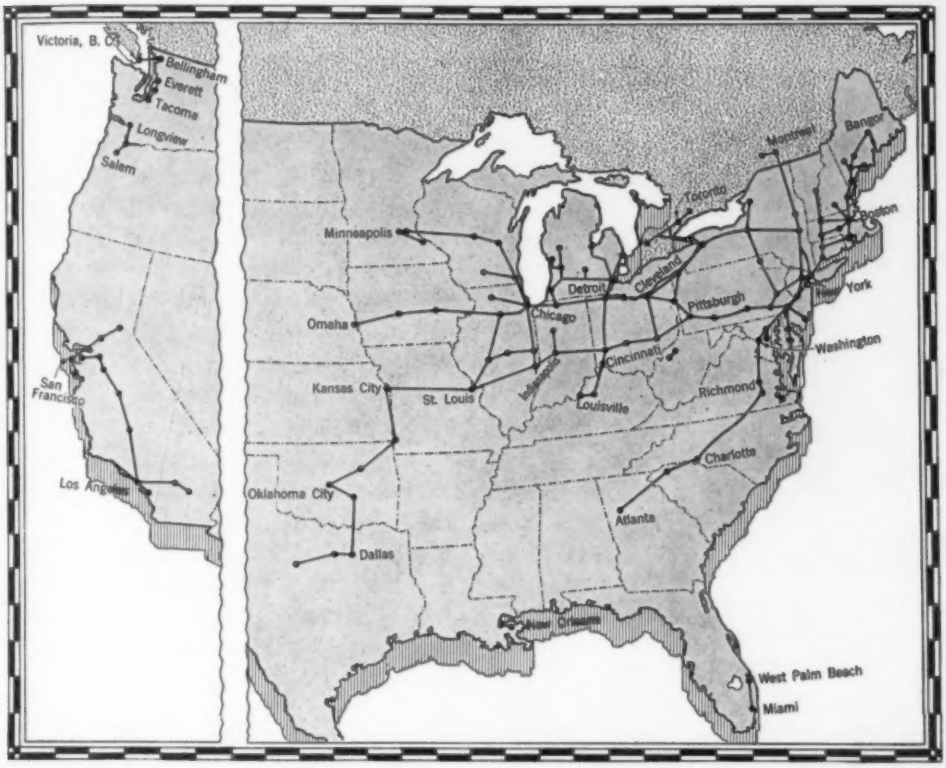


FIG. 15. THE BELL SYSTEM'S BASIC TOLL CABLE NETWORK

This map has been abbreviated to show only the arterial cable routes already in service. Many important additions are planned, including a 1,600-mile extension from Omaha to San Francisco, touching Denver and passing through Cheyenne, Salt Lake City, and Reno, and thus providing cable circuits from coast to coast, on which work is being begun this fall

as high as 25,000 lbs. Consequently, ice accumulations on aerial cable, even if accompanied by wind, do not have the adverse effect that they do on open wire, and relatively high line strengths can be obtained for aerial cable lines rather easily and at moderate cost. For this reason aerial cable becomes a practically storm-proof plant. Such a line is shown in Figure 14, which is a photograph of a long distance telephone cable extending from Greenfield, Massachusetts, to White River Junction, Vermont. Incidentally, this cable remained continuously in service during the hurricane of September, 1938, despite the fact that after the storm it was necessary to remove many hundreds of trees which had been blown across it.

CABLE placed in underground conduits, or specially protected cable buried directly in the earth, is, of course, immune to the effects of ice and wind storms. It offers, as well, service insurance in other directions

as, for example, against trouble due to bullets or fire. In the Bell System plant there are more than 71 million miles of exchange wire (i.e., wires used for providing local telephone service), of which approximately 65 per cent is underground, 32 per cent in aerial cable, and the remaining 3 per cent in aerial wire. Of the System's 16 million miles of toll wire, about 43 per cent is underground, 41 per cent in aerial cable, and 16 per cent in aerial wire. The fact that the percentage of aerial wire is greater in the toll than in the exchange plant is due largely to the fact that the smaller number of toll circuits makes it more difficult to justify cable economically.

The Basic Cable Network

IN Figure 15 is shown the Bell System's basic arterial network of long toll cables. There are, of course, thousands of other cables not shown which are either tributary to these or which make up an interlacing network between the primary routes. These primary routes offer a practically storm-proof service over the more densely settled portions of the country and are being constantly extended as fast as they can be justified from service and cost standpoints. One of the latest of these to be completed is the new cable between Stevens Point, Wisconsin, and Minneapolis, which, together with an existing cable from Chicago to Stevens Point, connects Minneapolis and St. Paul with the backbone cable network.

This new cable, of the coaxial type to carry several hundred messages ultimately, was for the major part of its length placed underground by means of a specially designed train of power-operated equipment which takes the cable from the reel on which it is supplied by the Western Electric Company and installs it underground at depths of 36 to 48 inches as conditions demand. In Figure 16 is shown an installation train consisting of the cable plow pulled by two tractors and followed by the reel on which the cable is delivered. A similar cable installation is now being made between Washington and Baltimore to supplement existing cables between these cities. This new cable is being placed over a route well separated from the existing one, to provide further service insurance. Work is also beginning this fall on an important extension from Omaha to San Francisco which will provide cable circuits from coast to coast.

THE fact that there appear to be considerable areas not yet covered by these backbone cable routes does not mean that adequate protection is not being given in these areas against possible interruptions due to storm damage. In the section from the mid-west to the Pacific coast, for example, there are four transcontinental open wire lines: one from Chicago through Minneapolis, Fargo, Bismark, and Helena to Seattle; another between Omaha and San Francisco via Denver, Cheyenne, and Salt Lake City; and two southern routes to Los Angeles and San Francisco, one from Oklahoma City and the other from Dallas and Fort Worth. In addition, there are north and south tie-lines both along the Pacific coast and east of the Rocky Mountains. In the event of failure of the most northern route, for

example, service to Seattle from the east can be furnished over the central or southern routes via either San Francisco or Los Angeles. Such service insurance is likewise furnished in the southern states through a similar network which provides for alternative and emergency routings.

It might be of interest to note here that the installation of new toll cable is now under way between Amarillo, Texas, and Tucumcari, New Mexico, to overcome difficulties with ice storms which have caused some interruptions to the open wire circuits in this section of this southern route.

TELEPHONE communication cannot be simply a fair weather service, for its value is often greatest when conditions are worst. To ensure continuity of service, plans must be made in good weather to meet conditions in bad. Adequate strength margins must be included in new aerial plant and maintenance must keep this strength at proper levels. Nature is no respecter of persons or things, and when she cannot be met by frontal attack she must be overcome by circumvention—by the substitution of aerial cable for open wire, by placing cables underground, by the provision of alternative routes for backbone circuits, and by providing a plant which has the flexibility which will permit of rapid adjustments in time of emergency.

To the telephone engineers this never ending battle against the destructive powers of the elements is fascinating. It is a fair fight, a continuation of the one begun when primitive man first sought the caves to escape those same elements. In this modern age the struggle has countless ramifications. As we are so often reminded, our civilization is built on power, transportation, and communications. The public resents even temporary failures on the part of any one of these three great servants. In the telephone field, as in the others, the public's standards become more and more exacting. The telephone engineer does not decry this but, instead, seeks new ways to circumvent the whirlwind attacks which less and less frequently result in interruptions to telephone service at the time it is most needed.

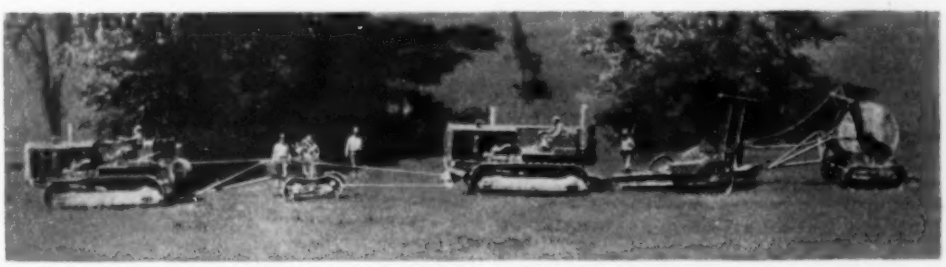


FIG. 16. PLOWING TELEPHONE CABLE UNDERGROUND

This powerful tractor-plow-trailer train places cable underground to a depth of three to four feet, the cable being fed automatically from the reel at the rear through the plow directly ahead

AT THE CUSTOMER'S SERVICE

Residence and Business Services and Equipment Are Available in Wide Variety to Meet Telephone Users' Many Different Needs Conveniently, Efficiently, and Economically

By JUDSON S. BRADLEY

THE growth in number of telephones in the United States to the present record total of more than twenty-one millions is a well-known fact, as is their geographic distribution throughout the length and breadth of the country. Less well known is the wide variety of telephone services, and of the instruments through which these services are rendered. Indeed, so many are there and so different and often specialized are their applications that only those in the business who in one way or another have directly to do with them can be well acquainted with them all. Yet, since they are one measure of the scope of Bell System service, some description of the more outstanding of them may be of general interest.*

A beginning may well be made with the services and telephones which are available for residential use, since they are fewer and less complex than those which may be needed for a large business installation. And the logical place to start is with the line between the subscriber's premises and the central office.

An individual line is preferable, of course, since it is used only in the subscriber's own service. A "party line," shared with others but having a lower charge, may prove satisfactory if the family is small and the use, both outward and incoming, limited. Nor is one line the ultimate. A large household, whose members have many interests and activities, may very well have two central office lines—or more. It is not unusual for a big estate, or even an elaborate apartment, to be as well equipped telephone-wise as a business office.

Central-office lines connect with telephones. Of the latter, half a dozen kinds, at least, are available for household use.

The handset, lying in its mounting, and with the bell box placed inconspicuously nearby, is appropriate to any room. So is the combined handset, which includes, in a larger base,

* Omitted from consideration here are certain services and equipment of such specialized application as not to be of general interest; also long distance and teletypewriter services, and public telephones, which have been described in previous issues of the QUARTERLY.

COMFORT AND CONVENIENCE

Few things contribute more to domestic ease than telephones in the right places

the bell and necessary electrical equipment, and thus eliminates the bell box.

The handset can be had, just as readily, to hang on the wall or to be affixed to a shelf; it is most convenient for kitchen, pantry, hall, or other location where space is limited. A portable telephone can be plugged into special outlets much as are electric fans or vacuum cleaners, offering a courtesy in the guest room and a step-saver in other parts of the house. There is a telephone made especially to fasten permanently on the wall; the desk telephone is still available if one prefers that type; an outdoor telephone comes in weather-proof case for garden, tennis court, or elsewhere about the grounds. Indeed, if harmony in the decorative scheme of any room is important, telephones can be had in dark gold, old brass, oxidized silver, statuary bronze, dark blue, gray-green, ivory, old rose, or Pekin red.

IF some member of the household has impaired hearing, the amplifying equipment which can be connected to any telephone may be a real blessing. Developed to help the partially deaf to use the telephone freely, it offers varying degrees of amplification of the voice in the receiver, the loudness being varied by a control button. While it is a permanent installation, it is connected and disconnected by the flip of a switch, and the telephone is always available for use by those of normal hearing.

In the big-city one-room apartment,

A PORTABLE TELEPHONE HELPS HERE

Many hospitals are equipped for this service, which can bring cheer during lonely hours and keep the patient in touch with home or business affairs

a telephone doubtless meets the situation fully. Double the number of rooms, and you lessen the convenience of one telephone; for if it is handy by the bed at night, it means running into the bedroom to answer it or to make a call during the day, while if it is in the other room, the ease and protection of the bedside telephone is lacking. Thus in a two-room home an extension as well as the main telephone may prove convenient; and the change from one room to two illustrates the point that, as the number of rooms increases, so does the importance of having more than one telephone.

A home of two or more stories which has but one telephone is—as a generalization—not only inconveniently but inadequately equipped. Better in every way is a minimum of one telephone on the first floor and one on the second, not only to save running up and down stairs, but to make it possible to answer a call before the caller concludes that no one is at home and hangs up, his call unanswered.

Still more convenient are an extension in the master bedroom, another in the kitchen, and the main telephone in the living room, library, or other convenient location. The larger the home, the greater the need for extension telephones, for in the modern household, equipped with up-to-date appliances from radio to vacuum

cleaner and electric refrigerator, its members will not expect to deprive themselves of the convenience of telephones where they will be handy.

Auxiliary Equipment

"I HOPE it's for me" said the headline of a recent Bell System advertisement which pictured the members of a family all hurrying to answer the telephone. Obviously, the bell had rung, and its sound was an expectant summons. Perhaps chief of all the advantages of the telephone is that it is a *two-way* medium of communication, and consequently there must be some signal to let us know when someone wishes to speak with us. But the familiar b-r-r-r-ring is not the only kind of bell, nor, indeed, is it always the most desirable form of signal. There are bells of different tones, such as the signal which strikes one soft musical note—but since this can scarcely be heard beyond one room, it is usually not the only bell in the house. Louder bells—gongs, really—can be installed where it is necessary to hear them at a distance.

Lights, too, may be used as signals, although in the home they are generally used only as supplements to bells. Where there are two lines, for example, a common bell can serve to announce a call on either one and differently colored lights at the telephone show which line the call is on. Two bells of different tones would, of course, accomplish the same purpose. Like the bells, the lamps are designed to fit various needs.

There may be times when the sound of a bell is not desired. Particularly is this true of a bedroom extension when there is sickness or when the bell would interrupt needed sleep. A remedy for this is a simple little switch which cuts off the extension bell—but not the telephone—until it is thrown "on" again. Another switch, equally simple, will disconnect all extension telephones at will, thus insuring absolute privacy of the conversation over the telephone in use. Again, a call may be answered at one telephone and another person summoned, by

EFFICIENCY IN THE KITCHEN

The hang-up handset makes it possible to keep an eye on the cooking while holding a conversation

means of buzzer signals, to answer it at another telephone.

WHEN two or more central-office lines enter the home, all lines may be used for both outgoing and incoming calls, of course—although in some households it is the practice to limit service calls to one line, so that the other line or lines may be always free for use by members of the family. Since an establishment large enough to require several lines will have extension telephones in all important rooms, both family and service, it becomes increasingly convenient—important, in fact—to be able to use them for intercommunication throughout the house and other buildings. Likewise, the service must have flexibility: it must be so arranged that incoming calls may be answered either at any telephone or at certain designated telephones; that a call may be transferred readily from one telephone to another; that a call may be held at one telephone while another call is placed to a different instrument; and various combinations of these and other features which meet the needs of the ménage.

All of these needs, in their many variations, and to the greater or less extent required, may be provided for through the many standard layouts which meet almost any requirement. The simpler layouts call for only the wiring and the buttons and keys; the more complex arrangements take, additionally, a cabinet in some out-of-the-way location to house the necessary associated equipment. Simple or complex in planning and installation, they are all easy to use, and bring to the big home or the more modest domicile a convenience in proportion to the needs they serve.

Lines, instruments, extensions, signals, switching arrangements:—even these brief descriptions give some idea of how broad is the scope of residence telephone service. On the subject of the telephone in the home, there is, however, a final point to cover: the telephone directory.

THE directory, of course, furnishes the subscriber's telephone address. Normally, one simple listing gives all the necessary information:

Doe John r 123 Main 4567

If Mr. Doe carries on a business under his own name, however, he may prefer to have both business and residence telephones listed thus:

Doe John ofc 321 State 6745
residence 123 Main 4567

If he has more than one central-office line, he may prefer to have this kind of listing:

Doe John r 123 Main 4567
Service 5678

If Mr. Doe's residence is in the suburbs, for instance, and his service is furnished through an exchange other than that of the nearby city, he may carry in the latter directory a listing like this:

Doe John r 123 Main Othertown
(Dial Operator) ..... Othertown 4567

One way or another, the directory can make Mr. Doe's residence easy to locate, easy to reach by telephone. That is fine for him and Mrs. Doe. What about other members of the family? If there is in the household someone with a different surname—nephew or in-law, for example—that person may have an individual listing.

Without it, only those who know, and remember, that Mrs. Richard Roe makes her home with John Doe will be able to reach her; to others she will be telephonically anonymous.

So we see that even as prosaic a compilation as the telephone directory can add greatly to the convenience of residence telephone service.

The Great Variety of Services and Equipment for Business

MUCH wider is the field of business services and equipment. Discussion of them may conveniently start, as did the previous section, with the matter of lines—about which there is not a great deal to say. For, invariably, the individual central-office line is the principal servant of business, be the requirements of an enterprise met fully by a single line or by two score.

As for telephones:—all those which were described earlier as suitable for residence service have their places in business, and there are numerous others for special uses.

Many an executive office is fitted with a telephone in bronze or other metallic finish, or, if the decoration is modernistic, with one in color. The hang-up handset keeps desk or counter unencumbered. The desk set still works as well as ever. The wall set also has its place. The outdoor telephone, in its weatherproof housing, is most often useful on loading dock, in supply yard, or other exposed location. Portable telephones find a variety of business uses.

The amplifying equipment has a further refinement often helpful to the business man whose hearing is impaired: a microphone, to be placed on desk or table, which is connected with the amplifying circuit. A person's words addressed to the microphone are stepped up through the equipment to the telephone receiver, to which the hearer listens as to an ordinary telephone conversation. Operation of this equipment does not exclude incoming telephone calls.

OUT OF THE WAY

The hang-up handset in the office keeps desk or table surface clear

In addition to telephones which are equally useful in home or business, there are others which have been designed primarily to meet some particular use in business.

Such as telephones in elevators, for instance. With one in each car, and connected through a switchboard,

FREE TO MOVE ABOUT

Operator's head-band receiver and chest transmitter, and plug-in (portable) telephone connection, give this clerk freedom of action and speed her work

they insure smooth operation and dispatching on schedule—a prerequisite to any pleasing and convenient transportation service. And should an elevator become stuck, it is most reassuring for the operator to be able to take down a handset and report the trouble.

An operator's telephone, composed of head-band receiver and chest transmitter, is another specialized piece of equipment. Worn regularly by central office operators and by attendants at busy P.B.X. switchboards, it is also a convenience to those who have to do much telephoning or carry on long conversations. Head band receivers, either single or double, are also available for use with a desk telephone; they leave the hands free for writing.

A recent development is a telephone intended for use in plants where the atmosphere may contain such explosive gases as hydrogen, natural or manufactured gas, or vapors of ethyl, ether, gasoline, acetone, alcohols or lacquer solvents, etc. It is so designed that any possible spark is confined within the interior of the instrument.

Allied to telephones—in fact, to be connected with them—are two types of loud speakers which will amplify incoming messages so that they may be heard satisfactorily by groups of up to 100 and 250 respectively. The loud speaker can be switched off and the telephone at the same location switched on, so that two-way conversation between the near and distant points may be held, and the circuit can even be arranged so that both sides of the conversation are audible through the loud speaker. The advantages of loud-speaker hook-up for addressing sales meetings, conferences, etc., over either local or long-distance circuits are obvious.

ALL the types of signals previously described for residence use have their application to business, and there are others too. Bells and gongs up to 10 inches in diameter can be furnished in either indoor or outdoor style, for use in noisy locations or where they must be heard at a distance, and there is a double-ended klaxon-like horn which rivals John Peel's view halloo as likely to waken the dead.

FOR THOSE WITH IMPAIRED HEARING

The volume of amplification of the voice in the receiver is controlled at the small device at the side of the desk

Lamp signals are much more used in business establishments than in homes. The man whose incoming calls reach him through a P.B.X. switchboard may prefer to have them announced by the lighting of a lamp rather than the ringing of a bell, particularly if his secretary has an audible signal at the extension on which she picks up his calls. If more than one line terminates at his telephone, lamps will indicate which line has a call for him or which line is already in use. Many circuit arrangements in offices, stores, and plants find light signals helpful, and with some they are an essential part. Lamps, alone or grouped, may use a bulb no larger than a dime in diameter; bee-hive lamps, so called, are larger and more readily visible; installation of proper relays makes possible the use of a big and brilliant lamp corresponding to gong or horn and useful in similar places.

CODE-CALLING systems summon an individual not at his regular telephone when there is a call or message for him. Signals at suitable locations may be single-stroke bells, musical notes, horns, or flashing lights, and customarily the individual hearing or seeing his code responds to the P.B.X. attendant from the nearest telephone. One type, entirely separate from the regular telephone system, is, however, usually operated by the P.B.X. attendant, who pushes a button—one of a number in a small cabinet—corresponding with the code signal of the individual to be called. Another

CONVERSATION BY LOUD SPEAKER

This group is listening to an incoming telephone call which is being amplified through the loud speaker on the table

type, which may be installed in association with dial P.B.X. systems, permits the direct dialing of a code signal. The musical tone signals often heard in hospitals or department stores indicate a code-calling system in operation. Paging by means of loud speakers accomplishes a similar purpose and is not, obviously, limited to messages in code.

Meeting Varied Needs

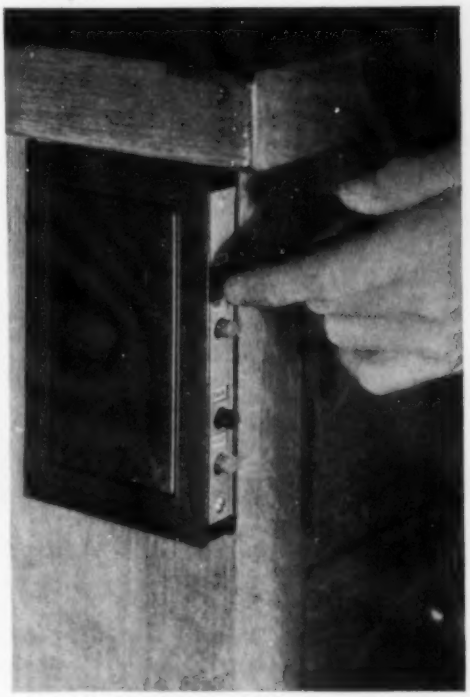
PERHAPS the one thing most conspicuous in a general consideration of switching systems for business use is not their number nor their variety, nor even the ingenuity of some of their arrangements: it is their ability to provide service to meet almost any imaginable communication need. One business may require a switchboard big enough to serve a fair-sized city, miles of wire, hundreds of telephones. Another needs perhaps no more than a pair of telephones so interconnected that a call may be made or answered at either. The first often requires careful study of the situation, special engineering, many man-hours of manufacture and installation. The second will call for no more than wiring according to a stock diagram. Yet no matter how complex the requirements, or how simple, once they have been determined, they can be met.

We are likely to think of switching systems and switchboards in association, yet they are by no means inseparable. Switches, keys, and buttons, with proper wiring, can afford a vast flexibility of communication. One or two features of telephone layouts in residential use were described earlier; others can only be mentioned in the space available here.

Given one central office line or more, and two or more telephones, these layouts can be arranged to provide any or all of the following services: place or receive calls on all lines

at one telephone; cut off from a given line all telephones but the one in use; cut off bells; hold a call on one line while making a call on another line over the same telephone; signal and talk between telephones on the same premises without a central office connection. All these things may be accomplished without the aid of an attendant. There are more than 20 standard layout plans for groups of telephones, and about a million Bell telephones equipped with them.

Recently developed is equipment which provides similar services by means of push buttons in the base of the combined handset. Telephones come equipped with one, four, or six buttons, with provision for a maximum of six central office lines and various combinations of the features mentioned in the preceding paragraph. Optional on any of them is a new and ingenious exclusion key for cutting off extension stations. Incorporated in the right-hand bracket of the combined set mounting, it must be pulled up by hand, after lifting the handset, to exclude other telephones on the line, but the act of replacing the handset automatically restores the key to normal—a boon to forgetful users. These systems differ basically from other layouts in that each telephone may be equipped with features to meet the user's wishes.



FLEXIBILITY

Such buttons operate the several features of a telephone layout: in this instance they permit the holding of a call on one line while talking over another line through the same instrument

STILL other types of equipment concentrate a number of lines in a cabinet with keys and lights, so that, for example, the telephones connected with those lines can be answered at a central point when the regular users of the telephones are not at their desks to answer them. Up to forty lines can be so concentrated, and the cabinets are fitted with lights to signal incoming calls and lines in use, and with keys for answering and holding calls. A typical use would be in an office which is the headquarters for salesmen who are out much of the time. An incoming call to any one of their telephones will be signaled at the cabinet, and a secretary can answer and, if necessary, hold the call while she obtains information over another of the lines multipled through the cabinet. Where two persons facing each other across a desk are to use a

AT ONE'S FINGER TIPS

The buttons which control the various operations of a telephone layout are incorporated in the base of this instrument

cabinet, it may be had with facilities to permit both to use it at the same time.

IF communication is the blood stream of business, then the private branch exchange switchboard is the heart of every sizable organization, for through it circulate its telephone calls: incoming, outgoing, and among its members. While the arrangements heretofore described have performed varying services, as dictated by the needs they met, the P.B.X., whether manual or dial, has one principal function: to switch calls.

Smallest and simplest of the manual P.B.X.'s are the key switchboards, small cabinets which may be placed on desk or table. The two sizes have provision for, respectively, three central-office lines and seven extensions, and five central-office lines and twelve extensions. Calls are answered at a telephone wired into the circuits, and switching is by the manipulation of keys on the face of the cabinet. Such switchboards best serve businesses whose traffic volume is not large; they are also useful, for example, to supplement for a department or group the main P.B.X. switchboard which serves the organization as a whole.

When the volume of calls necessitates either more central office lines or more extension telephones within the organization, a cord switchboard may be called for. As the name indicates, calls are completed by connect-

KEY EQUIPMENT

When Dr. Smith, Mr. Richard, and others are away from their offices, this young woman answers their calls by means of the small cabinet on her desk

ing the various lines by means of cords, just as connections are made in manual central offices. Standard cord P.B.X. switchboards have capacity for 10 central office lines and 30 or 40 extension lines, and for 15 central office lines and 80 or 320 extension lines. Depending largely on the traffic load, a switchboard as large as the last named might require the services of two attendants, at least during peak hours, and so be equipped for two positions.

More lines would, obviously, necessitate more positions, and multiposition P.B.X. switchboards are available to serve large organizations. While they are manufactured in standard sections, they are usually installed after a careful survey of the premises they are to serve and the service features they will be called on to provide.

As with manual P.B.X. equipment, there are dial P.B.X. switchboards of many sizes to meet various service needs, ranging upward in capacity from the small cabinet operated by means of keys and a dial-equipped telephone to one capable of handling hundreds of lines. A particular advantage of a dial P.B.X. layout is that members of the organization may dial both their outgoing and their intercommunicating calls direct, without assistance from the P.B.X. attendant. Attendants customarily handle only incoming calls at the P.B.X. For this reason, the switchboard itself of a dial P.B.X. will usually require fewer positions and at-

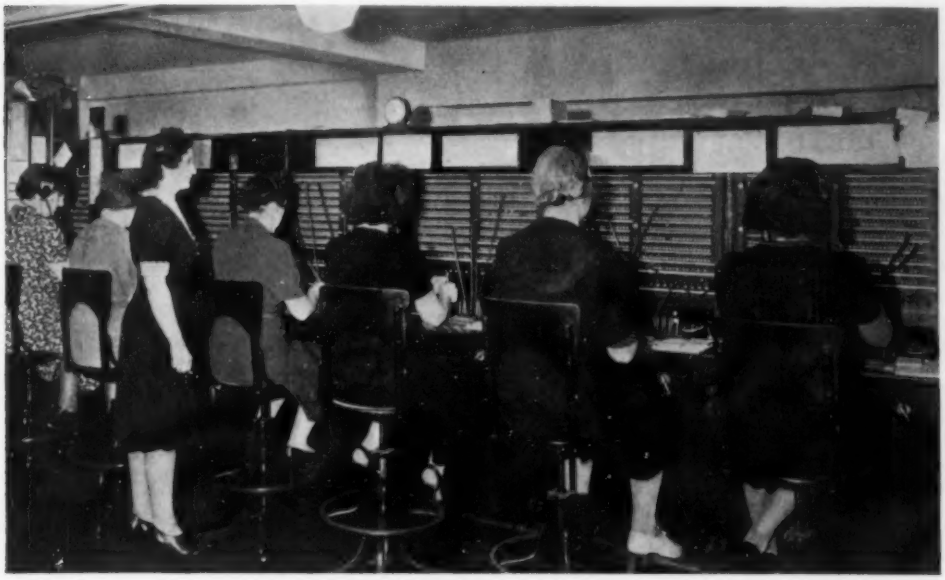
A SMALL PRIVATE BRANCH EXCHANGE SWITCHBOARD

This key switchboard has a capacity of three central-office lines and seven extensions

tendants than a manual P.B.X. to handle the same number of calls; but the dial P.B.X. system has, of course, the equipment for the mechanical switching of calls which is not required with the manual system.

This is not to say that big dial P.B.X.'s require only a few manual positions and attendants. Many a department store, railroad system, bank, or other large business organization has a dial P.B.X. which serves hundreds or thousands of telephones through miles of wire and requires the services of dozens of attendants who are as thoroughly trained as are the operators in a telephone company's central office. Big P.B.X. switchboards, and all that goes with them, whether manual or dial, are engineered and installed pretty much on a custom tailored basis.

FOR a detailed account of the many features of P.B.X. switchboards, and of all the kinds of service which may be rendered through them, there is no room here. But, since a P.B.X. is only a means and not an end, some mention must be made of the ends it serves. It will—in simplest terms—connect a central-office line and an extension telephone for inward or outward calls, and will connect one extension telephone with another for inter-communication. But tie lines may join P.B.X. switchboards on the same premises, in different buildings, or even in distant cities; special connections may be set up for night service after the attendant



A LARGE P.B.X. INSTALLATION

Such a private branch exchange switchboard, with its staff of highly trained attendants, can handle thousands of calls a day

has left; the switchboard may be equipped for conference service, so that several people, both on and off the premises, may take part simultaneously in the same discussion. Or a big P.B.X. may reach a smaller P.B.X. which, in turn, serves a department or group. Or it may connect with order receiving equipment.

ORDER receiving equipment is designed to do one particular job: to answer large numbers of similar incoming calls at a centralized location, and to do it quickly, smoothly, and to the satisfaction of customers. As the name indicates, it is used mainly by department stores, taxicab companies, newspaper classified advertising departments, public utilities, and other organizations with which the public places many orders which may be handled by trained attendants.

The equipment comes as a cabinet to be placed upon a table, and is double-sided: that is, arranged in the center of a table so that attendants on each side have access to the lines between them. Since this sort of order taking is likely to be somewhat of a continuous performance, attendants customarily wear chest transmitter and head-band receiver, leaving both hands free.

Order receiving equipment, like other telephone apparatus, is very flexible in the variety of possible arrangements. It may be connected by trunks to a central office, thus giving customers direct access to the order-taker; it may be reached by extension lines through the firm's P.B.X. switchboard; or a combination of these routes may be employed. It may or may not be equipped to make outward as well as to receive inward

ORDER RECEIVING EQUIPMENT

The clerks in this telephone order department receive thousands of calls from the store's customers every day

calls; it may or may not be linked by tie lines with another switchboard, another order turret or table, or telephones in various departments, on the selling floor, etc. Since the equipment is manufactured in units, these units may be installed side by side to make as large an installation as the incoming business calls for.

THE directory listings already described in connection with residence telephone service are generally applicable to business telephones as well, and there are other ways in which the directory can serve business. Consider these, for instance, which tell their own story:

Doe John J atty ofs 321 State 6745
res 123 Main 4567
If no answer, call 9876

Doe Mfg & Supply Corp
Main ofc 232 High 5065
Warehouse 454 Elm 7346
Garage 213 State 3794
Nights, Sundays & Holidays call 2038

Transfer of toll charges, whereby department stores, wholesalers, and similar organizations invite customers to call in from "foreign" exchanges without charge, is based, in several different forms, on listings in directories other than the one covering the community in which the organization is located. A department store may arrange to have a listing of which this, for example, is representative, in directories serving exchanges in surrounding towns:

Doe Dept Store 123 Main Centertown
Ask operator for ..... WX 1000
(No toll chg for WX calls)

Calls for WX 1000 are then automatically accepted by the operator as collect toll calls to be charged to the Doe Department Store.

A firm may lease a line to a distant city and list a local number in the latter directory. This gives the firm local representation, telephonically

speaking, even though the two ends of the line may be hundreds of miles apart.

Of importance to business men are their classified listings in the "yellow pages," as the classified section of the telephone directory is known. If a firm handles several different lines of merchandise, such as, for example, building materials, weatherstrips, roofing, it can be listed in the yellow pages under each one. Many firms find it desirable to take advertising space in the "yellow pages" to describe their business in a manner to attract prospective customers.

In these ways, and in others not detailed here, the directory becomes an adjunct of telephones which serve business.

INCOMPLETE though it is, this itemization must have conveyed some conception of the variety of ways in which the telephone industry is able to provide services, and the instrumentalities through which those services are rendered, to meet the communication requirements of its customers in almost any form which they may take.

But it is not enough to have all these services, all this equipment, available. Customers must be informed of them, and they must have help in deciding just what particular arrangement will best meet their individual needs. This has led to the development of a special job in the telephone business, that of the customers' communication adviser. This calls for a knowledge not alone of telephone services and equipment but also of business problems and business operations, and for the ability to analyze these as a basis for determining how customers can use the telephone most economically and most efficiently in their businesses.

That the Bell System is able to meet practically any communication need is no accident. Just as, in engineering its buildings, switchboards, and outside plant, the System plans ahead against the demands for service which the future will bring, so does it study today's needs, and anticipate tomorrow's, for the *types* of service and the *kinds* of equipment which will be most fruitful of good for every telephone user. Through the years, one instrument after another has been superseded by another still better, one type of equipment has suggested the usefulness of another type, one kind of service has revealed the opportunity for another kind. As it has been from the beginning, so is it today: studies are continuing, laboratory experiments and models are in process, field tests are being carried on, to the end that the people of this nation may find the telephone of tomorrow serving them in home and farm, in factory and store and office, as steadfastly as it does today—and better.

TESTING AMERICA'S EARS

Records of More Than Half a Million Individual Tests at the Bell System Exhibits at Two World's Fairs Provide the Most Extensive Data Ever Compiled for the Study of Hearing

By FRANKLIN L. HUNT

How good are your ears? This question, which is of personal interest to everyone, has been answered for over three million people by means of tests they have taken at the Bell System exhibits at the World's Fairs in New York and San Francisco during the past two years. More than half a million of the individual tests were recorded for study by the Bell Telephone Laboratories, thus providing by far the most extensive data on the hearing of the American people ever compiled.

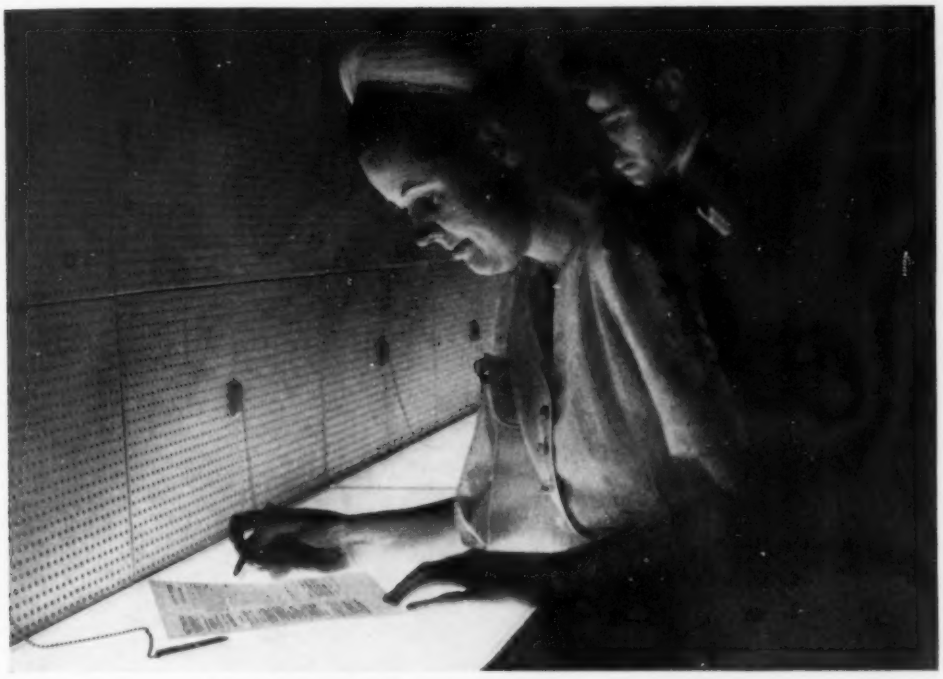
For many years the Laboratories has carried out studies on the characteristics of hearing, for this is the intangible stuff that telephony is concerned with, and knowledge of the behavior of the ear is essential to the maintenance and improvement of telephone service. In keeping with this effort, World's Fair visitors were offered the opportunity to test their hearing.

Information on hearing acuity has previously been limited to tests made on comparatively few individuals. The results of the much more extensive survey at the World's Fairs indicate, as did the previous tests, that there is a definite decrease in hearing acuity with age, particularly for the higher frequencies. At the lower frequencies the loss is small and somewhat less for men than women, but at the higher frequencies men lose considerably more than women.

The tests were made in sound-proof rooms, each of which accommodated seven visitors in partially screened sections. Seated at a table, with a card at hand on which to record the results, the person tested held a telephone receiver to his ear and listened to spoken words or tones which were repeated, with variations—each time fainter than before.

In the word test the visitor heard a series of two-number words, such as "eight five." As successive numbers were spoken, they were recorded in a column on the card, until they became too faint to be heard. When twelve pairs had been announced, the test was repeated with a different series.

Pure musical tones were used in the other test. There were five of them, an octave apart, extending upward from 440 cycles per second—



CHECKING THE HEARING-TEST CARDS

Light passing through the card reveals all the tones which could have been heard and indicates whether the individual's hearing is "normal or good," "slightly impaired," or "impaired"

which corresponds to A above middle C on the piano—to 7040 cycles per second. Beginning with the lowest, the tones were sounded in groups of from one to three pulses—at first loud enough to be heard easily and then fainter and fainter, in from 6 to 10 decibel steps, until only audible by those with exceptionally acute hearing. The number of pulses heard each time was recorded in a column on the card. When the series for the lowest tone had been completed, the tone an octave higher was sounded, at first loud and then progressively fainter. The complete test showed five rows of figures on the card, each corresponding to a different pitch. On the back of the card was printed in reverse the correct number of pulses sounded. By holding the card so that light passed through it, these numbers could be seen and they provided a check on the accuracy of the numbers written down by the visitor. Designations "normal" or "good," "slightly impaired" and "impaired" also showed through the card opposite the 8th, 5th and 2nd steps respectively, to give a qualitative indication of the hearing acuity. From these tone-test cards the hearing studies were made.

Before the person tested left the room, he was asked if he would allow his record to be photographed for

TAKING THE TESTS

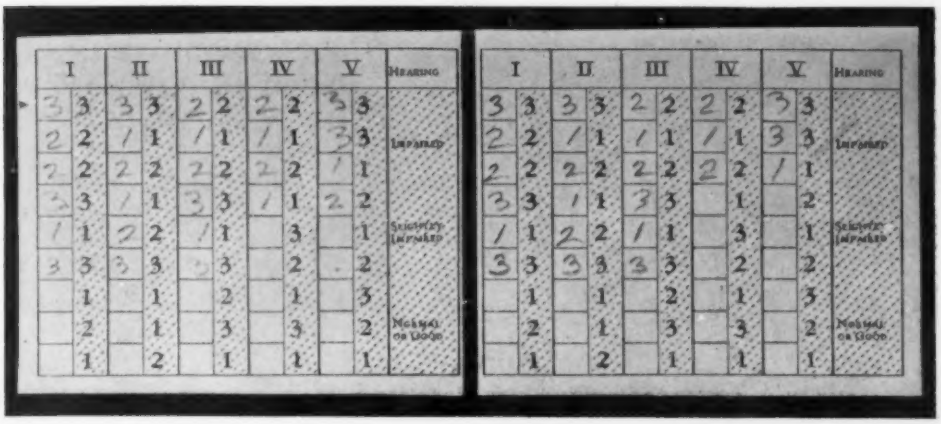
Sound-proof rooms, each containing individual sections such as are shown here, were used at both World's Fairs

analysis. Permission granted, the attendant put a check mark on the card in code to indicate whether the visitor was male or female, white or black, and to which of the five age groups 10–19, 20–29, 30–39, 40–49 or 50–59 he belonged.

A photographic record of the card was then made on 16-millimeter film in a Recordak machine, after which the card was returned to the person tested. These records were transferred to punch cards later at the Laboratories, by an operator who viewed the film in a projector. The punched cards showed, besides the results of the hearing test at each frequency, the age, sex, and the date and hour when the test was made. The data were summarized by running the cards through a tabulating machine.

Equipment for the Tests

To assure that the test tones and the numbers spoken in the word test were always the same, they were recorded on "hill and dale" disc records and reproduced through a standard high-gain amplifier. The recordings were made at a constant level and the fainter levels were attained by switching in attenuating resistance pads between the amplifier and the listener's earphone. This provided a flexible



I		II		III		IV		V		HEARING
3	3	3	3	2	2	2	2	3	3	
2	2	1	1	1	1	1	1	3	3	IMPAIRED
2	2	2	2	2	2	2	2	1	1	
3	3	1	1	3	3	1	1	2	2	
1	1	2	2	1	1		3		1	SERIOUSLY IMPAIRED
3	3	3	3	3	3		2		2	
	1		1		2		1		3	
	2		1		3		3		2	NOTHING OR LITTLE
	1		2		1		1		1	

I		II		III		IV		V		HEARING
3	3	3	3	2	2	2	2	3	3	
2	2	1	1	1	1	1	1	3	3	IMPAIRED
2	2	2	2	2	2	2	2	1	1	
3	3	1	1	3	3		1		2	
1	1	2	2	1	1		3		1	SERIOUSLY IMPAIRED
3	3	3	3	3	3		2		2	
	1		1		2		1		3	
	2		1		3		3		2	NOTHING OR LITTLE
	1		2		1		1		1	

HEARING-TEST CARDS

These are representative of the average woman (left) and the average man (right) in the 50–59 year group. The many blank spaces in the last two columns indicate loss of hearing

method of adjusting the attenuation and prevented record scratch or noise in the amplifying system from disturbing the listener, particularly for the faint sounds. The pads were connected into and removed from the circuit by a crossbar switch whose contacts were closed by a selector switch operated from a cam geared to the phonograph turn table. To synchronize the tones with the crossbar switch, a notch on the edge of the record fixed its position on the turn table.

Attendants operated the mechanism by a remotely controlled starting mechanism and the equipment stopped automatically at the end of the test. When the starting button was pushed, an auxiliary motor lifted the pick-up from the record and placed it at the starting point. The turn table and synchronized mechanism then started automatically. When the test was completed the turn table stopped and a lamp lighted to indicate that everything was ready for another test. At the New York Fair there were eighteen of these machines and at San Francisco there were four.

To assure a constant output level, the machines were checked carefully each day with a special test record, and all the telephone receivers were tested periodically. Listening tests were also made daily by the engineers in charge and by the attendants.

THE walls of the booths where the tests were made were covered with sound-absorbing material and the floors were carpeted. This assured a low noise level in the test booths. The masking effect of outside noise, as calculated, was less than 5 decibels at the lower frequencies and zero at the higher ones. As a further check, members of the Bell Laboratories' staff who had taken the test at the Fair were retested at the Laboratories under conditions free from disturbing noise. The average improvement was about 3 db at 440 cy-

SOURCE OF THE TESTS

The test tones and numbers were reproduced from "hill and dale" phonograph records through amplifiers to assure constant quality and control of intensity

cles, 1 db at 760 cycles, and the differences were negligible for higher frequencies. Part of this improvement may have been due to repetition, but it indicates the maximum effect of surrounding noise.

Findings from the Tests

THE actual losses in db for both men and women for the next to the lowest and next to the highest frequency tested are shown on page 273. Women 55 years old heard the 800 cycles-per-second tones 3 db less well than men, but 3520 cycles they heard 7 db better. For the 10–20 year group there was practically no difference at the lower frequencies and not more than 3 db at the highest frequency. The hearing of the youngest group was found slightly poorer than that of the next older, but it was believed that this was principally due to difficulty which the younger children had in understanding the test procedure.

The difference in the hearing acuity of men and women is also shown on page 273, where the hearing loss for all of the frequencies tested is given for the 10–19, 30–39, and 50–59 year groups. Young men and women hear about equally well at low frequencies, but the women hear about 3 db better at 7040 cycles per second. The difference is much more pronounced, however, in the older group, where men hear about 3 db better at low frequencies, while the reverse holds at the higher ones to the extent of from 5 to 10 db. Zero hearing loss in all of these tests is taken as the hearing acuity of the average of both men and women in the 20–29 year group. This reference level corresponds closely to that for no hearing loss on the 2A Audiometer.

Test cards, as they appear for the average woman and man for the group 50–59 years, are shown on page 269. The lighter numbers at the left of each column are those written down by the person tested, as he listened to the tone pulses. The heavier numbers at the right are those which become visible when light passes through the card; they show the number of pulses actually sounded. Loss of hearing is indi-

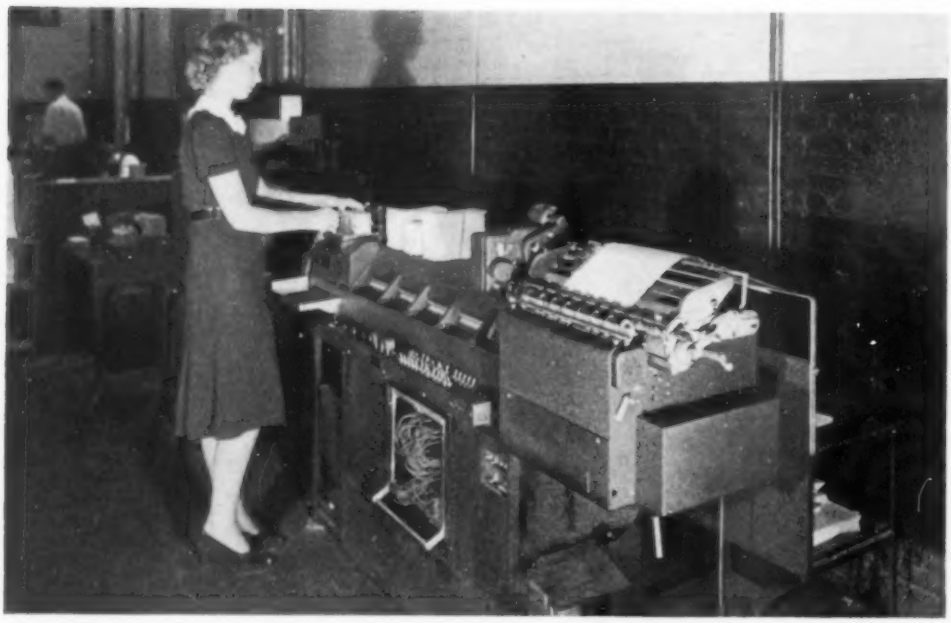
RECORDING RESULTS FROM TEST CARDS

The cards were recorded on 16-mm film, and results were later transferred to "punch cards" by an operator who viewed the film in a projector

cated by the numerous blank spaces in the last two columns. The average young person could hear the first six or seven tone steps but missed the faintest two or three. From 10 to 15 per cent of the youngest group, however, and from 1 to 2 per cent of the oldest group, could hear the faintest sounds.

THE ability to understand speech usually can be predicted from the average hearing loss up to 1,760 cycles per second. An indication of the significance of hearing losses of various magnitudes may be obtained from the collective judgment of deafened people as reported in a survey conducted several years ago by the United States Public Health Service. In that survey, people with hearing losses of 25 db or higher reported difficulty in hearing in auditoriums and churches. Difficulty in hearing direct conversation when the speaker is two or three feet away was reported by people with hearing losses of 45 db or higher, and people with this much loss usually need a hearing aid. Only those people with hearing losses of 65 db or more reported difficulty in hearing telephone conversation.

Combining this information with the World's Fair test results indicates that one out of 25 persons has difficulty in hearing in auditoriums, one in 125 has trouble with direct conversation, and one in 400 has sufficient hearing loss to cause difficulty over the telephone. It is also of interest that only three out of 200 of the young people who took the hear-



SUMMARIZING RESULTS

The hearing test results were summarized by running the punched cards through this calculating machine

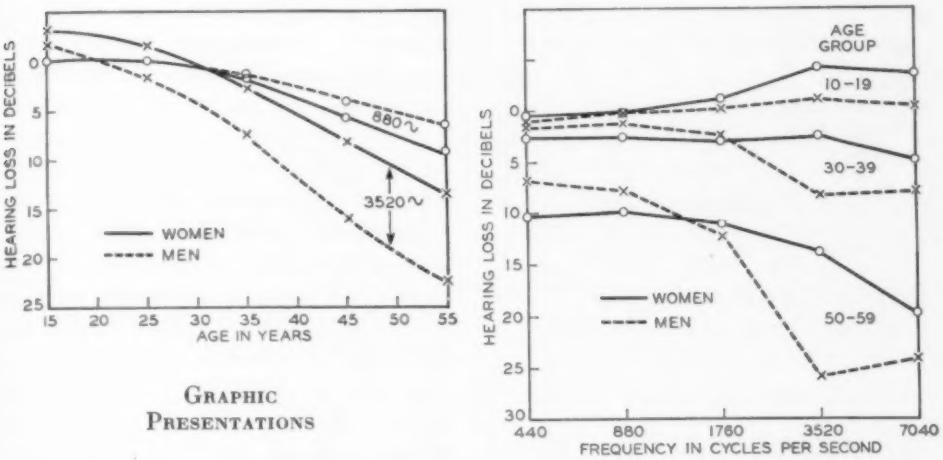
ing test at the Fairs had as much as 25 db hearing loss but that 10 times as many in the oldest group showed this much impairment.

Considering the hearing acuity at the higher frequencies, the World's Fair tests indicated that two out of five men between 50 and 59 years of age showed a loss of at least 25 db at 3,520 cycles per second but only half as many women have this much loss. The tests also showed that one in 20 of the group 10–19 years of age has a loss of 25 db at 7,040 cycles per second, whereas half of the oldest group have losses of this magnitude.

Age and Residence Factors

THE age of those participating in the hearing investigation was estimated by the attendant from their appearance. Approximately fifty different attendants served each week and they were changed about once an hour. To determine the accuracy of the estimates, the actual ages of over two hundred members of the Bell Laboratories' staff and their families, who took the tests without identifying themselves, were compared with the ages recorded on their cards. It was found that 83 per cent were not more than three years outside of the group to which they were assigned.

Comparison of data taken at New York with that from San Francisco for the age groups below 50 years gave no conclusive evidence of sectional differences in hearing. At the three lowest frequencies the differences were insignificant. The results



GRAPHIC PRESENTATIONS

Left: Men hear low frequencies somewhat better than women, but women hear the higher frequencies considerably better than men. Right: Hearing acuity for all frequencies decreases with age and the loss is greatest at the higher frequencies, particularly for men

at 3520 and 7040 cycles per second indicate that the hearing loss of the men who took the test at San Francisco was on the average about 3 db greater.

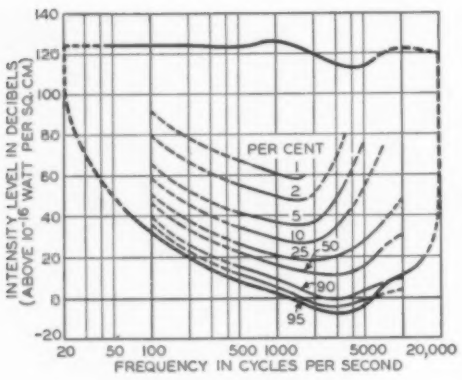
During one week at each fair visitors were asked to indicate on their cards whether they lived in the city where the fair was held, within commuting distance, or beyond. The replies showed that about a quarter of them lived in the city and another quarter were commuters. Although sectional differences in hearing are not very definitely indicated by these tests, the differences found suggest that a more detailed geographical grouping, which also considered past places of residence, might disclose substantial differences.

By observing the appearance of visitors as they handed in their test cards for photographing at the New York Fair, an effort was made to obtain data on the relation of hearing acuity to economic status. Individuals were classed as average and above or below average. The hearing acuity of those above average in personal appearance was found somewhat better.

THE possibility that fatigue might affect hearing acuity was considered. Test cards from both Fairs were studied to see if variations in hearing occurred with the time of day. No consistent difference was found, and it was concluded that there was no appreciable change in hearing between morning and evening for any of the age groups tested.

Comparison of data taken at New York during early summer with that obtained in the fall of 1939 showed no definite difference. This not only indicated that there was no appreciable change in hearing acuity with change in season but it also gave a check on the stability of the test equipment.

A few people, mostly in the youngest age groups, falsified their cards by filling in numbers not heard, but it is



HEARING LIMITS

The lowest curve shows the faintest sounds of different frequencies that a person with excellent hearing can hear; the top curve shows the loudest sounds that the average ear will tolerate. The other curves indicate the faintest sounds that people with different amounts of hearing loss can hear; the figures on them show the per cent of the population having that degree of hearing impairment

believed that the number of these included in the tests was too small to affect appreciably the hearing distribution.

The Fair visitors were probably above average in economic status, intelligence, and education, and it is possible that the hearing of the population as a whole is not quite so good as the tests indicate. Careful consideration of all the known factors leads to the conclusion, however, that the results represent very closely the hearing acuity of the people of this country.

Hearing Loss in the Population

THE hearing tests made at the New York and San Francisco Fairs included a large but not entirely representative section of the people of this country. The age distribution of the visitors was somewhat different from that of the entire population, since the very young and the very old were not adequately represented. By weighting each of the six age groups according to their proportion in the whole population, however, the amount of hearing loss for the ages 10–59 years was computed. The results are shown at the left, where the lowest line indicates the faintest sounds of different frequencies that a person with very good hearing can hear, and the line at the top shows the loudest sounds that the average person can tolerate. These curves were determined by previous investigations.

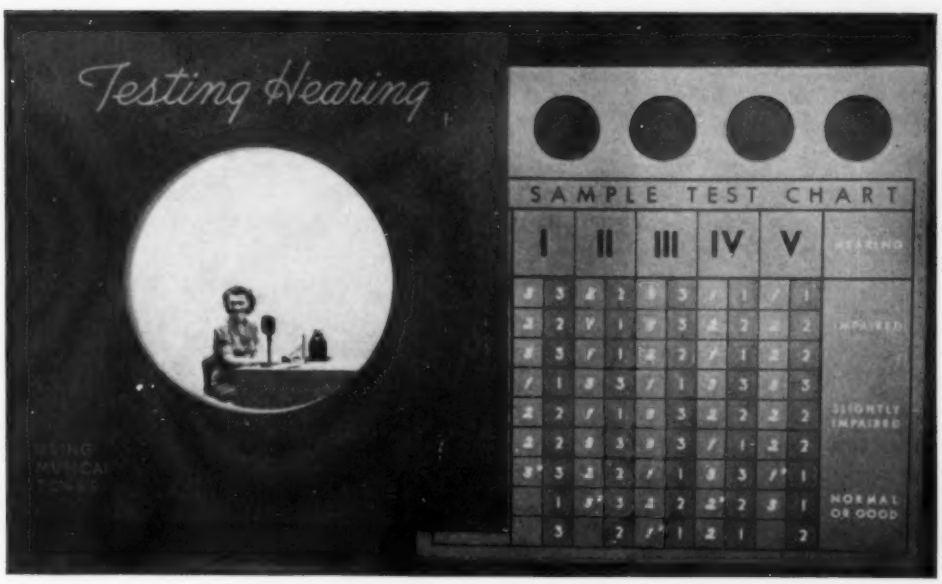
The other curves, based on the World's Fairs' data, indicate the faintest sounds that people with different amounts of hearing loss can hear and the figures on them show the per cent of the people who cannot hear sounds below these intensities. The intensities are shown at the left of the diagram in decibels. Dotted lines indicate extrapolated values. These results should be applied with caution to groups of unusually high or low economic status without further knowledge of the relation between hearing and these factors.

Some normal ears are more acute than the average and others less acute. This makes it important to determine what deviations are associated with the beginning of deafness, particularly among young people. Studies of the Fair data indicate that a smaller hearing loss at low frequencies than at high is significant for both sexes, and that a given loss at high frequencies is more significant for girls than for boys. About 5 per cent of the boys and girls in the youngest group tested

had hearing losses at low frequencies which were great enough to cause an appreciable impairment, and from 6 to 8 per cent had such losses at high frequencies.

To help those whose hearing is impaired, the Bell Telephone Laboratories has made available the results of its studies on hearing and the transmission of speech, in the practical form of audiometers to determine their hearing acuity and of audiphones to make good at least in part their hearing loss. Another device, developed for telephone studies, which is helping to teach those with hearing impairment to talk more naturally is the magnetic tape-recorder. This instrument records spoken words magnetically on a steel tape and reproduces them with increased loudness, thus providing a valuable aid for teachers of the hard of hearing.

We have progressed a long way from the traditional ear horn in recent years. Much more effective aids, both preventative and remedial, are now available to those whose hearing is impaired; and it is a satisfaction to the Bell System to have been able to contribute to this cause, through studies which were undertaken primarily for an entirely different purpose, namely, the improvement of the telephone.



WINDOW DISPLAY

To attract visitors and explain the hearing tests, a large illuminated chart was installed in the Bell System exhibits at both Fairs. An attendant behind the round window flashed numbers on the chart as she explained the tests with the aid of a public address system

A NATION-WIDE SOURCE OF SUPPLY

The Western Electric Company's seven factories and twenty-nine distributing houses from coast to coast serve the entire Bell System

The Western Electric Company's seven factories and twenty-nine distributing houses from coast to coast serve the entire Bell System

FINAL STEPS IN SUPPLY DISTRIBUTION

The Plans Developed to Insure a Continuous Flow of Supplies to Employees on the Job Are Vital Links in the Chain of Bell System Construction, Maintenance, and Operation Activities

By H. CARL RUTH

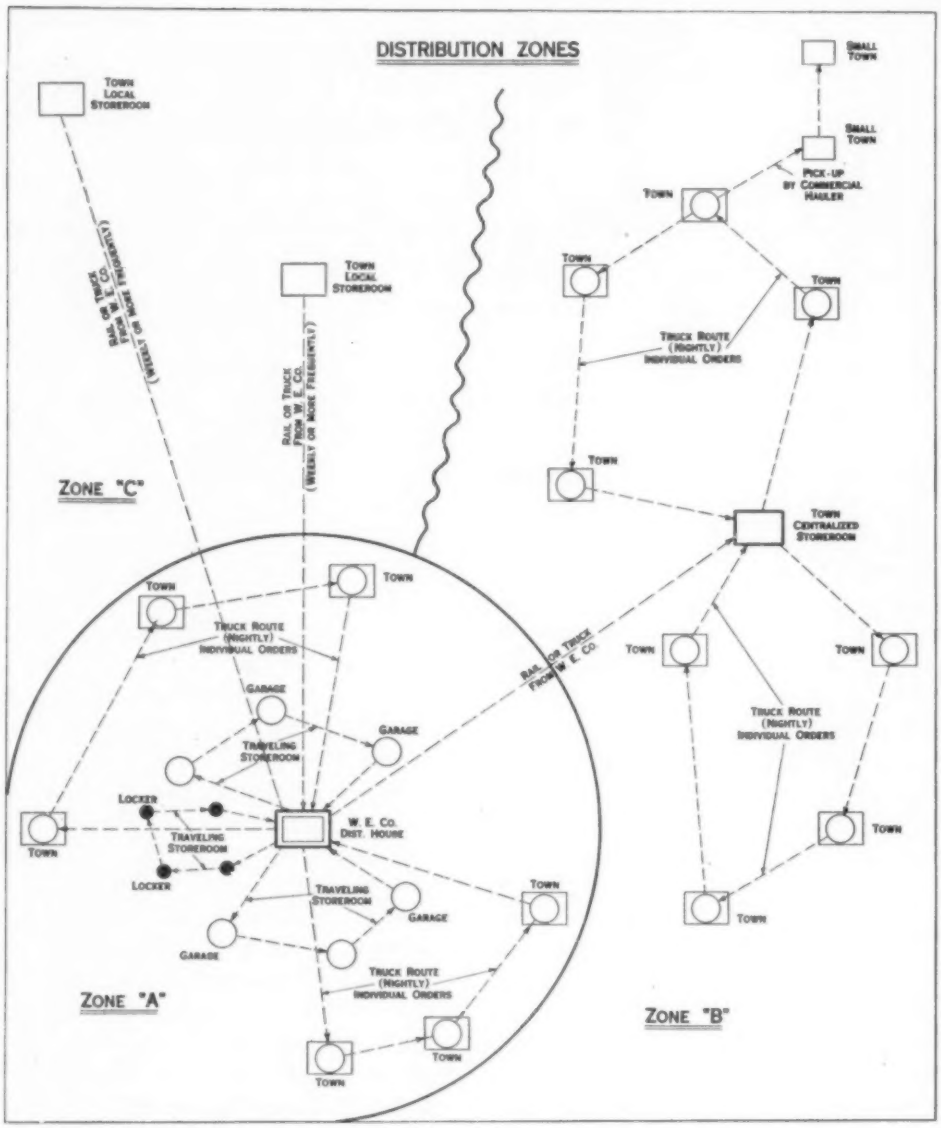
EVERY working day, the two hundred and seventy thousand employees of the Bell System operating companies use an average of more than six hundred thousand dollars' worth of supplies. Thousands of different items, ranging from a reel of cable weighing several tons to a telephone set or a pencil, must be made available in an orderly and economical way to these workers who construct, maintain and operate this business throughout the nation.

The central source of supplies is, of course, the Western Electric Company, which is the manufacturer and purchasing agent for the Bell System. Western Electric maintains central stocks at its factories and at its twenty-nine strategically located distributing houses throughout the country. The phase of supply distribution dealt with in this article is the movement between these distributing houses and the telephone company employees located in the thousands of communities where Bell System service is furnished to the public. It is the responsibility of the telephone company supply organization in each operating area to provide the methods and facilities that enable the individual employee to have on hand the particular items he needs each day.

The distribution of supplies is not alone a problem of applying the best transportation methods, for many related supply activities must precede and follow the actual transportation between the distributing house and the delivery locations in the telephone company.

Forecasts of requirements for the important items must be prepared to aid in determining manufacturing and purchasing schedules. The output of rehabilitated equipment from the repair shops in the distributing houses must be calculated in advance. Requirements for new items must be estimated. All these are for the purpose of furnishing the Western Electric Company with background information to aid it in maintaining adequate stocks of needed supplies.

The employee needing supplies must know the proper name for each item, the size or code number, the quantities in the standard packages, and whether it is carried in stock at



SCHEMATIC DIAGRAM OF VARIOUS TYPES OF SUPPLY DISTRIBUTION

Zone A represents direct distribution from a Western Electric distributing house, Zone B illustrates nightly deliveries from a centralized storeroom, and Zone C shows distribution through localized storerooms

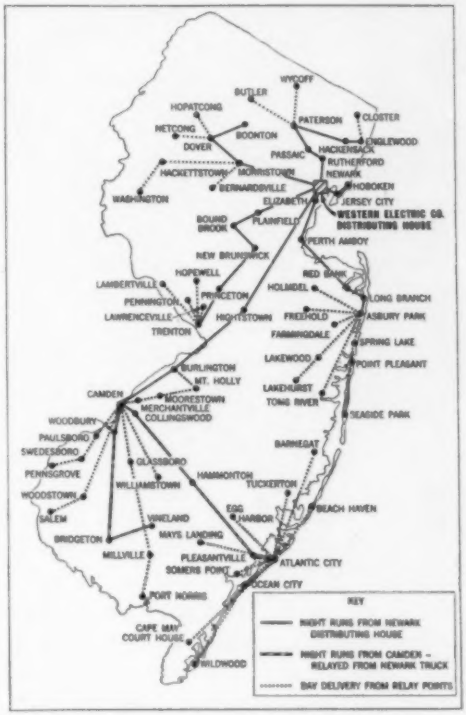
the distributing house. A catalog of supplies is his guide, and the issuance of periodic catalog revisions is a necessary part of the supply work in the telephone companies. Order forms and requisitions are designed in such a manner as to aid the individual to secure the supplies he needs. For the

use of the specialized crafts in the Plant Department, the requisition forms are imprinted with the names of the frequently used items.

System in Supply Distribution

IT is essential that each distributing house receive an orderly flow of requisitions from the telephone company. Proper time allowances must be made to permit the distributing house to select the supplies and pack them for shipment. Trucking routes must be planned and the time intervals calculated for other forms of transportation from the distributing house to the locations designated by the telephone company. All these factors are carefully coördinated by the telephone company supply organization and the distributing house personnel in preparing the ordering and delivery schedules. For each town, city, and building, and by principal classes of supplies—such as plant supplies, stationery, house service supplies, etc.—the schedules show when each requisition is due at the distributing house and when delivery will be made. The ordering dates are coördinated with the delivery routes, so that the supplies ordered by the various force groups are delivered simultaneously to each building. Copies of these schedules are furnished to all employees who order and return supplies.

As an integral part of the distribution job, the telephone companies' supply organizations must also handle annually some fifty million dollars' worth of telephone sets and other supplies removed from plant, returning them to the distributing houses for testing, repairing and refinishing by



DIRECT DISTRIBUTION IN PRACTICE

There are no storerooms in the territory of this Bell System company, truck routes from the distributing house covering the entire state

the Western Electric Company repair shops.

Furnishing the proper types of tools for use by each of the various crafts in the Plant Department is likewise a part of the distribution work. Records of tools in the possession of the various individuals are maintained by the telephone company supply organization, repair standards are set up, and programs aiding in the education of the field forces in the day-to-day upkeep of tools are initiated.

Supervision of the flow of material to prevent unnecessary accumulations of supplies in the field is an important phase of the telephone company sup-

ply work. Supply inspectors visit each storage location periodically and also inspect the supplies carried on the work trucks. With their advice and guidance, and with the keen interest of Plant supervision in orderly arrangement and orderly procedures, the field forces have steadily decreased the stocks of supplies carried in the field as related to the quantities they use daily.

The territories utilizing the facilities of Western Electric's distributing houses present varying problems of geography, density of population, types of telephone plant, rate of growth, and organization. Hence, no one detailed plan of supply distribution is applicable to the entire territory of every telephone company. Each operating division must be studied individually and the appropriate plan or combination of plans carefully worked out by the telephone company's supply organization. Engineers of the supply section of the Plant Operation Division of the American Telephone and Telegraph Company take an active part in establishing and improving distribution methods.

Supplies for the Plant Forces

THERE are more than 16,000 motor trucks in the Bell System fleet, each of them carrying supplies and tools needed for the day-to-day work. The supplies required for the routine construction and maintenance of the telephone plant are distributed to this vast fleet, via direct distribution plans, storerooms, and lockers, from the stocks at the Western Electric Company distributing houses by the telephone companies' supply organizations.

Major projects requiring large amounts of cable, conduit, poles, etc., however, must be scheduled in advance and shipped from the factories to the freight sidings nearest the job. The telephone company's supply organization carries on the distribution job from there to the various locations along the line in advance of the actual construction work.

It was the accepted practice for many years for the telephone companies to maintain a storeroom at each location where work trucks were garaged. The stocks in these storerooms were replenished by the placing of bulk requisitions on the distributing houses about once a week.

As the volume of business grew, many of the storerooms within the metropolitan areas surrounding the distributing houses started to place daily requisitions to replenish their stocks in order to meet their increased needs. This helped the storerooms to keep their supply investment at a reasonable level and gave them daily access to the larger stocks at the distributing houses.

It was customary under early methods of storeroom operation for Plant employees to come into the storeroom each morning and get the supplies they needed. In some of the companies, studies were made to ascertain the time required by these field forces to secure and also return supplies to the storerooms. This was found to be considerable in the aggregate, and the next step was the establishment of the so-called night-loading plan, whereby the employee left an order

STOCKING UP

Replenishing the portable shelving units carried in the traveling storerooms

each evening for the supplies he needed the next day. The storeroom force collected these orders each night from the trucks in the adjacent garage, selected the materials from the storeroom stock, and placed the needed supplies on each truck. At the same time the storekeeper picked up the recovered material. This reduced considerably the time required by the field forces to secure and return supplies.

As the types of supplies became more diversified and operating refinements permitted quicker installations of service for customers, it became apparent that the operation of telephone company storerooms was not the best answer for many places. The average large storeroom carried about 1000 to 1500 different types and sizes of telephone materials and tools, while the Western Electric Company distributing houses normally stocked two or three times as many. Rapid strides were being made in the field of transportation, freight shipments were being speeded up, commercial trucking concerns were starting to operate on close schedules, and the motor truck was rapidly coming into extensive use as a reliable medium of transportation. It was a logical step from the storeroom night-loading plan to the development of a distribution plan which enabled the supply organization to meet the individual employee's requirements directly from the stocks in the Western Electric distributing houses, thus eliminating, in the metropolitan areas, the need for storerooms. This direct distribution plan made available, to the field forces within daily delivery radius of the distributing houses, all of the large

stocks maintained there by the Western Electric Company.

Under this plan the employee uses an imprinted requisition to order items needed for his particular job. These requisitions are collected each evening by the supply deliverymen, along with any recovered material, and taken to the distributing house. The following morning a telephone company supply man reviews the requisitions and passes them immediately to the distributing house people. The supplies are selected as ordered on each requisition, separately packed, and later checked by a telephone company supply man. These individual orders are then grouped by locations and delivery routes, and delivered that night to the respective garages and work trucks by the supply deliverymen. Under this plan the supplies are available for use by the employee on the morning of the second day after he orders them.

It is of interest to note that this plan has been developed in one company to the point where there are no storerooms in its entire territory, the Plant Department being supplied directly from the distributing house by means of a system of truck routes covering the entire state.

The Use of "Traveling Storerooms"

To meet the operating requirements in a number of large cities, a further refinement has been widely adopted. This is known as the traveling storeroom plan for serving station installers and outside repairmen in metropolitan areas. When the entire motorized plant force is served on a direct individual order basis, as related just above, there is an interval of one working day between the time the employee prepares the order and when he receives the supplies. With the use of traveling storerooms the supplies for the station forces are delivered the same night the order is prepared.

These traveling storerooms are large motor trucks with specially designed bodies equipped to carry four portable shelving units. Upon these is carried a carefully selected stock of over 400 different items of station supplies and commonly used hand tools. A space in the front of the truck body is used to carry individual orders for the construction forces and for returning material recovered from plant.

At each garage on his route the supply deliveryman selects from the traveling storeroom stock the items indicated on the supply orders left by the station forces, and places each order in a canvas bag, which he leaves on the employee's truck. He then picks up a similar canvas bag containing the items which the employee has disconnected and wishes to return; this is placed in the open space in the front of the traveling storeroom truck. The direct individual orders for the construction forces are placed on the line construction trucks and splicers' trucks and any recovered material left by them is also picked up. Each traveling storeroom supplies the work trucks in three or more garages each night.

Upon completion of a traveling storeroom's night route, it returns to the Western Electric distributing

SHELVES FILLED

These units are now ready to be rolled, with others, into the traveling storerooms

house, where its portable shelving units are removed from the truck to be restocked by the telephone company supply force. The truck itself, meanwhile, is available for some other daytime service.

Before the advent of direct distribution, it was necessary for the telephone companies to maintain large garages in order to obtain the supply advantages of the adjacent storerooms. The direct distribution plan has eliminated this requirement and it is now practical, from a supply viewpoint, to house the work trucks in small groups near the job throughout the cities. This decentralization of the motor vehicle fleet has produced some operating economies by reducing the non-productive time of men and trucks in traveling back and forth from the garage to the job.

Under the direct distribution plan, each garage is equipped with a small steel locker which contains a few of certain types of station items which are needed occasionally but not required every day; for example, coin collectors, long cords, loud bells, etc. These items serve all the station force working from the garage, thus eliminating the need for each man to carry a stock of them constantly on his truck. The supply deliverymen review the stocks in the lockers nightly, replacing any items which have been used during the day. Where required, occasionally used tools such as manhole pumps, portable generators, blowers, long extension ladders, etc., are neatly stored on racks in a small enclosed space equivalent to that occupied by one truck. Small stocks of telephone directories for use of the installation force may also be kept in this space.

LOADING THE TRUCK

Placing the portable shelving units in a supply delivery truck transforms it into a traveling storeroom

IN the downtown business districts of most cities, it is neither practical nor economical to equip station installers and repairmen with motor trucks. Here the problem of supply distribution is of a different nature from that discussed so far.

Various methods have been used. For example, each installation and repair foreman would rent a small room for supply storage purposes, locating it as near as he could judge to the center of his local territory. Wood shelving was erected and the foreman ordered the supplies he needed for his force about once a week. This method had some drawbacks. The lack of factual data in deciding upon the location of these supply rooms in the downtown section of the city often necessitated walking long distances to the job assignments. The task of ordering, stocking, and returning supplies took considerable of the foreman's time, and the different arrangement of items at each location made it difficult for the men to find the supplies they needed when they were transferred from one location to another to meet the variations in work load.

UNDER the plan now in general use, the locker locations are determined by a detailed study of service order and station maintenance activities, without regard to the foremen's territorial lines. The volume of these activities is indicated, by city blocks, on a large scale map, and the centers of heaviest concentration are picked as the locations for the combined installation and repair supply lockers. These locations are usually in office buildings or stores. Steel lockers, which can be easily moved when the center of activities changes, are placed at each selected location, and stocked with predetermined types and quantities of station supplies. Both installers and repairmen use the same lockers, as much of the material used by these two force groups is identical.

In the downtown section of a typical large city operating under this plan, there will be about 20 locker locations serving about 160 walking installers and repairmen. These men secure their supplies for each job from the nearest locker. In general, no attempt is made to assign particular men continuously to specific locker locations and this permits shifting the force to handle sectional peaks in business without any supply compli-

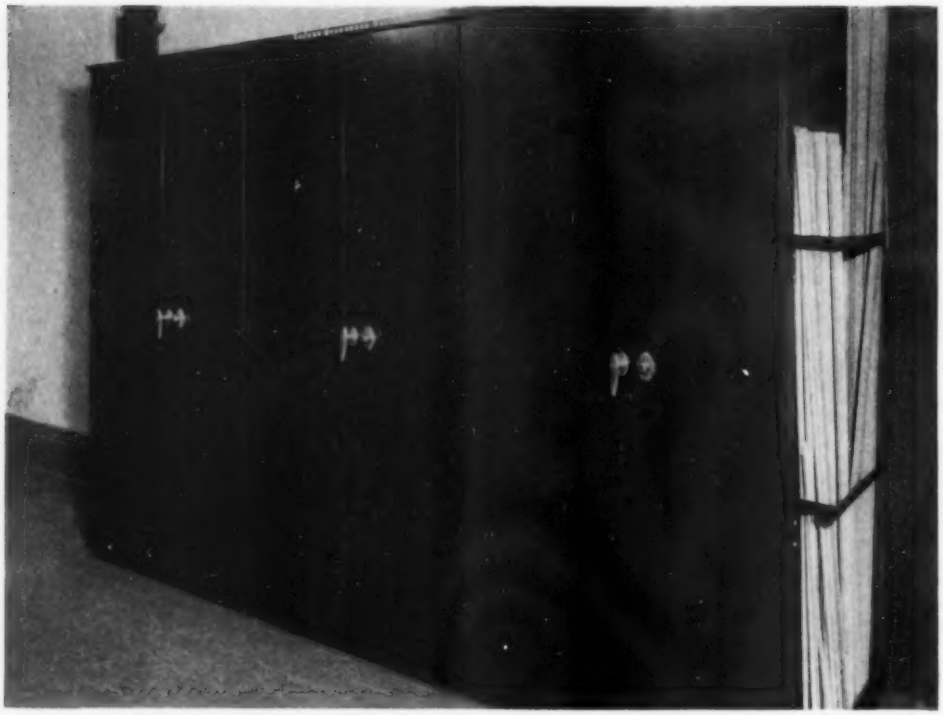
A TRAVELING STOREROOM IN OPERATION

From the shelves, requisitioned supplies are put in bags and placed on the work trucks in this typical garage, and items to be returned for reconditioning are picked up from the trucks at the same time

cations. It also reduces to a minimum the time spent by the employee in securing supplies, since he merely goes to the nearest locker for the items he needs. To aid the employee in locating the items, the supplies are arranged identically at every location and the shelving is labeled to show the name of each item and the authorized quantity.

NIGHTLY the supply deliverymen with a traveling storeroom motor truck visit each location to replace the items which were used during the day and to pick up recovered material. It is not necessary for the station forces to prepare any orders for this material; the supply organization does the entire job. Under average conditions, better than 90 per cent of the customers' orders for service and practically all of the station maintenance work are completed with supplies secured from the regular stocks in these lockers. Large jobs, such as private branch exchanges, teletypewriters, etc., and requirements for unusual items, are handled on individual orders and the supplies delivered direct from the distributing house to the customer's premises in the daytime or to the locker locations at night by the supply organization.

Recently, as the telephone density has increased and the automobile traffic and parking problem has become more acute, the use of this



SUPPLY LOCKERS IN CONGESTED DISTRICTS

In downtown business districts, where traffic congestion makes trucks inefficient, lockers such as these are installed in convenient rented quarters where Plant employees on foot have access to them

locker plan has been introduced in the business sections of smaller communities and in apartment house sections in the larger cities.

FOR a number of years it was accepted practice for the telephone companies to maintain storerooms in all towns where Plant forces were stationed. In areas far from Western Electric distributing houses, where the distances precluded direct distribution, the aggregate of these many storerooms represented sizable stocks, floor space, and handling costs. The supply service rendered by these storerooms was not in keeping with other service improvements because of the impracticability of carrying in each one the wide variety of supplies normally required. This arrangement resulted in many emergency requisitions being sent to the distributing houses and in the constant transferring of wanted supplies between storerooms.

With the great improvement in transportation, it was a logical development in supplies distribution methods for the telephone companies to establish a supply center or centralized storeroom, carrying diversified stocks, at many of their district or division headquarters in the outlying

areas. Each night the supply delivery trucks start from the central storeroom and visit the surrounding territory, delivering supplies to the work trucks, lockers, and buildings in the surrounding communities. Under this plan, the former inadequate small storage locations have been eliminated and a greater variety of supplies made available daily to the employees. Individual orders and traveling storerooms are both used for servicing these surrounding communities, dependent upon the telephone company's requirements.

The stocks at the central storerooms are replenished weekly or more frequently from the Western Electric distributing houses, the supplies usually being shipped by fast freight or long distance commercial motor trucks.

Beyond the direct distribution areas and outside the areas served by the centralized storerooms are remote communities where local storerooms must continue to operate. However, even in these locations the trend is toward smaller and more frequent shipments from the distributing houses, plus night loading of work trucks, standard types and quantities of storeroom stocks, and more accurate forecasts of local requirements, all of which aid in giving better supply service from these modern storerooms.

EVERYTHING IN ITS PLACE

Interior of one of the lockers shown on the opposite page

Supplies for Dial Central Offices

FOR many years most telephone companies operated one or more storerooms devoted entirely to stocks of dial central office maintenance supplies. Despite the size of these stocks and the voluminous records required to maintain them, it was frequently found necessary to call upon the Western Electric Company to furnish additional items on an emergency basis. A few years ago, studies were made in some of the companies of the entire dial central office maintenance supply situation, and it was found that many items which were currently required were being ordered in bulk from the Western Electric Company, placed in storerooms, and redistributed from there to the central offices.

Here again, due to improvement in transportation facilities, it was found practical and economical to eliminate

these specialized storerooms and improve the supply service by arranging with the distributing houses to fill the wire chiefs' orders directly. Infrequently used spare parts not stocked by the distributing houses are secured from the Western Electric Company manufacturing plants, if need be by air or railway express. Lists are prepared of the authorized types and quantities of the spare parts carried in the wire chiefs' lockers and the distributing houses. Ordering and delivery intervals are set up and included in the regular ordering and delivery schedules and plans developed for handling emergency requirements. This information is made available to all employees responsible for dial central office maintenance.

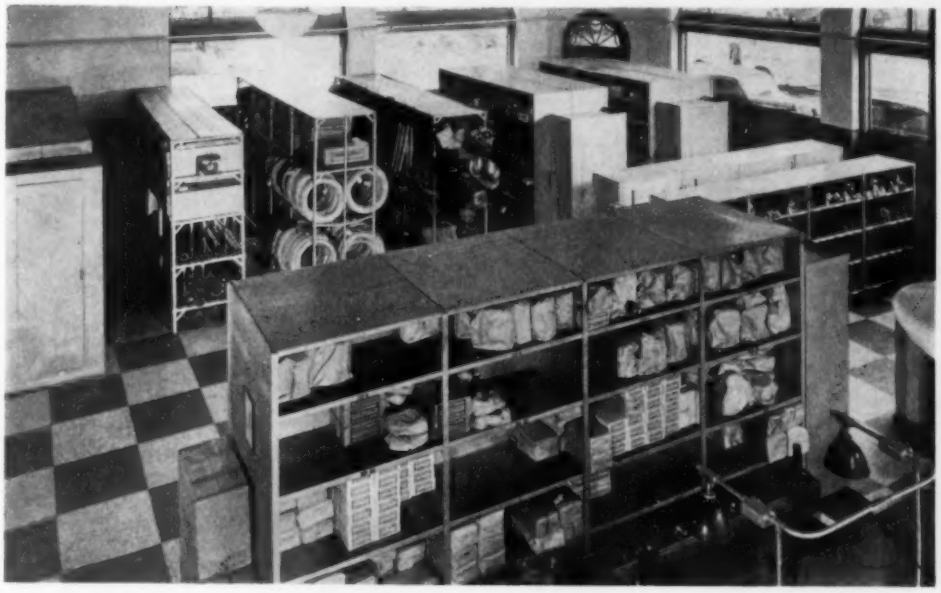
Building and Stationery Supplies

THE Bell System has a deservedly good reputation for excellent housekeeping in its buildings. While the men and women who do this job are by far the most important contributors to this spic and span appearance, the method of providing the cleaning supplies and other items used by them deserves some mention.

The modern plan of distributing building service supplies measures up to the appearance of the buildings. The requirements for each building are carefully studied. The amount of floor space, number of occupants, economical ordering quantities, and other important factors are used as a basis for determining the stock to be carried at each building. Well arranged lockers and shelving are labeled with the authorized quantities and types of supplies stored therein. Regularly, in accordance with the ordering and delivery schedule, a building employee reviews the stock on hand and compares it with the authorized quantity shown on the shelving labels. The difference in quantity, representing that which has been used, is inserted on a requisition form especially imprinted with all the commonly used items. This is sent to the distributing house and the supplies are delivered on the scheduled delivery day. Under this plan there is no guess work as to what and how much should be ordered; it is a simple clerical job easily performed by any employee.

THERE is hardly an employee of the Bell System who does not have occasion to use some items of stationery and printed forms in a normal working day. While the unit value of most of these items is small, in the aggregate they represent a considerable sum. In view of this comparatively low unit value, it is essential that the supply distribution plan operate in such a manner as to preclude, so far as practical, the necessity of placing orders for less than standard package lots. A close balance must be maintained between the value of the supplies being ordered, the average investment, and the cost of placing, filling and transporting the order.

During the past several years much progress has been made toward coordinating these elements, and the cost of distributing these supplies is being brought within practical limits as related to their value. Here again studies of the requirements at each



SUPPLIES ON HAND

This is a typical centralized storeroom serving a large rural territory

location enabled the telephone companies to set up authorized quantities and types of supplies to be carried. Stationery lockers at principal locations, with the shelving labeled with item names or form numbers and the authorized quantities, make the preparation of the periodic replenishment order a simple job.

In many companies it is customary to have stationery and printed forms stocked only at the district offices. The smaller locations and the individual employees are supplied from the district office stock as the needs arise.

What Happens in Emergencies

THROUGHOUT the Bell System the supply organizations have worked out, in coöperation with the operating departments and the personnel of the Western Electric distributing houses, smooth-running, efficient routines, adapted to conditions in their own territories, for getting supplies to their destined locations when and as they are required. And although this article is concerned principally with this routine of distribution under normal circumstances, the picture will be complete only if it includes some account of how supplies get to the man on the job when circumstances are anything but normal.

Floods, fires, tornadoes, sleet storms—all the catastrophic forces of Nature strike at telephone plant along with other structures of man's devising. No one can tell when or where the next blow will fall. But it is the tradition of the telephone industry to be ready always to repair the damage to its lines and equipment for the restoration of service just as fast as

its resources, knowledge, skill, and man-power permit.

The Bell System's resources include, of course, stocks of all sorts of supplies, from wire and cable to switchboards and solder and paraffin wax, in Western Electric's distributing houses from coast to coast. Back of these are not only further reserves in Western Electric's factories and the factories of outside suppliers, but the manufacturing capacity and skill to turn out additional great quantities of all sorts of equipment and supplies from plants which readily gear up to day-and-night operation when the need arises.

To get huge quantities of these supplies to the telephone men in a stricken area requires a special knowledge in routing shipments from distant factories to the distributing houses and to sidings and freight terminals nearby. Around blockaded areas, in express cars hitched to crack passenger trains, in convoys of trucks, by boat, even by chartered planes, the supplies may flow to strategic points, where they are turned over to the telephone company's supply organization. Then over icy roads or through snowdrifts or around blocked highways or washed out bridges, they continue until they reach the plant men working along the lines to restore the service.

INSTANCES of the abilities of the Western Electric Company and the telephone companies' supply forces to rise to an emergency are many. An illustrious one is that of the hurricane of September 21, 1938, when Western Electric delivered to the System operating companies in New England during the rest of that month and the first few days of October such quantities of supplies as—to cite but a few examples—607,000,000 conductor feet of lead-covered cable, 53,613,000 linear feet of drop wire, 16,632,000 prepared cotton sleeves, 2,039,000 pounds of pole-line hardware, and 21,800 telephone poles. Such quantities represent more than a year's supply of these items under normal conditions for the companies affected. Much of this material came, of course, from the distributing houses nearest the areas affected—particularly in the days immediately after the disaster. All of it had to be made available to the men on the job by the telephone companies' supply forces. Experienced supply men from other System companies were brought in to aid the local organizations, and, because of their practical experience with System distribution methods and System materials, were able to render immediate and substantial help to the local supply forces.

In the distributing houses, in times of emergency, work goes on as systematically as ever, but at greatly heightened tempo and often under most difficult conditions. If there has been a local power failure, night work continues under the beams of lanterns and flashlights, and men's backs carry loads when elevators are out of service. Typical of the will to maintain service was the instance of two men who lived for a week on the second floor of a distributing house whose ground floor was flooded, received orders by telephone, and passed stocks out the window to the

Operating Company's supply men who came alongside the building in boats.

THE men who direct the activities of the telephone companies' supply forces have their headquarters, as a rule, in the distributing houses. As in the normal routine, so in times of stress do the supply organizations work hand in glove with the Western Electric Company. Whether an emergency be major and widespread or minor and local, the telephone company's supply men are, because of their intimate knowledge of conditions in a given area, in a key position.

They must know transportation within their area, and have at their finger-tips lists of truckers to supplement their own vehicles and to undertake long hauls if the railroads are disabled. They must know at all times exactly where certain special cables and other vital equipment are stored. They must be well acquainted with all communities, so that they may readily locate temporary storerooms for supplies near to working forces. One way or another, with no lost time and with no lost motion, they must get the stocks where they are needed as they are needed.

Disasters are infrequent occurrences. But somewhere, every day, an emergency does happen—be it no more than a section of cable burned through by a blazing barn or a pole knocked down by an automobile out of control. Regardless of where the emergency occurs, and it may be hundreds of miles from the nearest Western Electric distributing house, the telephone companies' supply men must be able to produce at that location the cable or poles or whatever is required to mend the break. It is a matter of pride with every supply service man that no emergency restoration of service be delayed for lack of material. It is his job to get it to the spot—and he does.

PROVIDING materials under difficult conditions for the emergency restoration of service is dramatic. The day-to-day task of distributing supplies in orderly routine is not. But the supply organization which plays so great a part in enabling the Bell System to meet—and beat—emergencies, wherever they may happen and of whatever kind they may be, is the same organization which contributes to the smooth functioning of the telephone service by doing its normal, unspectacular job in thoughtful, intelligent, efficient fashion. To all the men who organize and direct and operate the ordering, stocking, and delivery of supplies, the maintenance of telephone service for the System's millions of customers is of first importance under all conditions.

THE CONQUEST OF A CONTINENT

The Successive Means Which Have Been Devised for Coast-to-Coast Communication Have Been Fundamental to the Growth of This Country and to Its Unity as a Nation

By ROBERTSON T. BARRETT

PART II*

PART I of the present study was devoted to a review of those facilities for overland communication between the Atlantic and Pacific coasts which antedated the use of steam for land transportation across the continent and the employment of electricity for the purposes of coast-to-coast communication. These included the famous Butterfield Overland Mail and the romantic Pony Express. With them were included, perhaps somewhat illogically, the Pacific Mail Steamship service, which was transcontinental only in a broad sense of the term, since its mails traversed only the relatively narrow Isthmus of Panama. Steam was, it is true, used in the vessels which carried these mails between New York and Panama, and between Panama and California and Oregon. As has been seen, after a relatively brief period during which mails were transported across the isthmus on mule-back, steam provided the motive power for this portion of the mail route.

* Part I was published in the July issue.

But as a factor in the physical transportation of messages across the 3,000 miles that measure the width of the United States, the railroad does not appear in the history of transcontinental communication until relatively late. Indeed, as has been pointed out, the coast-to-coast telegraph line had already become an accomplished fact before the first railroad linked the Atlantic and Pacific seaboards of the United States. Let us, however, depart from a strictly chronological treatment of our subject and, before discussing the telegraph and other forms of electrical communication, briefly review the history of the railroad and the airplane as instrumentalities of transcontinental communication.

The idea of building a railway to the Pacific was almost as old as the railway itself, as an American institution. In 1832, when the nation's first locomotives were still a novelty, a weekly paper published at Ann Arbor, Michigan, had proposed it. Three years later, Samuel Parker gave impetus to the movement when he argued for the practicability of such a

BUILDING THE UNION PACIFIC

Work on the last mile of the pioneer transcontinental railroad saw the "mingling of European with Asiatic laborers," according to the caption of this contemporary drawing from Harper's Weekly

road, basing his statements on personal observations made during an overland trip from Buffalo, New York, to the Oregon country.

Some Pioneer Railroad Projects

TEN years later, Asa Whitney, a New York merchant who had spent two years in China between 1842 and 1844, came forward with the most concrete of proposals which up to that time had been offered. A part of Whitney's project was a scheme (which, to say the least, was ingenious) by which he proposed that the road be built under government sanction, but at no cost to the public treasury. Although this proposal is only indirectly related to the actual building of a transcontinental road, it deserves more than passing mention.

Whitney estimated the cost of construction at about $65,000,000—a cost, by the way, that was not far from that of the first coast-to-coast railroad, completed more than a score of years later. He proposed that Congress grant him a tract of land sixty miles in width, running along the proposed right-of-way, and extending from Lake Michigan to the Pacific. This land he proposed to sell to city dwellers at low cost, thereby combining a much needed social reform with the objective of providing

transcontinental communication. The proceeds of these sales were to be applied to the cost of constructing the road. When finished, the railway was to be the property of the nation, and any profits derived from its operation were to be used for public education.

FANTASTIC though Whitney's scheme now seems, from a standpoint of financial soundness, memorials to Congress which he presented in 1845, 1846, and 1848 were given serious consideration, and his plan was endorsed by gatherings in numerous cities, as well as by the legislatures of sixteen out of the thirty states which then constituted the Union. There seems to have been in the man himself something of the fanatic, and yet in the following declaration, contained in his third memorial to Congress, there is evidence of the disinterested public spirit that, mixed with less altruistic motives, is the basis of all great communication enterprises. He says:

> "My desire and object have been to carry out and accomplish this great work for the motives, as here and everywhere else by me declared, to give my country this great thoroughfare for all nations without the cost of a dollar; to give employment to and make comfortable and happy millions who are now destitute and starving, to bring all the world together in free intercourse as one nation. If it is feared that the remuneration will be disproportionate to the extent and importance of the work, then I am willing to relinquish any claim I may have for compensation, and let the people give me anything or nothing, as they please. If they will but allow me to be their instrument to accomplish this great work, it is enough."

The route which Whitney suggested was, of course, primarily intended to link the newly settled Oregon country with the East. In considering his first two memorials, much thought was given to its political importance, and one Congressional report discussed the possibility that this distant region might organize itself into a separate nation if not linked to the rest of the country by better means of travel and communication.

California to the Fore

BUT before the third memorial came up for consideration, two events of far-reaching importance had occurred, either of which would probably have doomed the Whitney proposal. A war with Mexico had been fought and won, and vast territory, lying along the Pacific to the south of Oregon, had been acquired by the United States. Oregon was no longer the sole consideration in discussing plans for a railroad to the Pacific. Moreover, gold had been discovered in California early in 1848. The rush of treasure seekers—the famous "Forty-niners"—into the gold fields made it certain that, when such a railroad was built to the Pacific, its western terminus would be nearer than Oregon to the center of population of this newly developed area. Economic needs—and, later, political needs—were to determine the route of the projected coast-to-coast railroad.

Even as early as the date of Whitney's third memorial, in 1848, the same political factors which entered into the debate over the choice of route for the Overland Mail were making themselves felt. As sentiment for a railroad to the Pacific grew

AN INCIDENT OF RAILROAD BUILDING IN THE WEST

The jet of steam projected forward from above the engine's cylinder was the regular means of scaring buffalo off the track. (From a painting owned by the Union Pacific Railroad)

stronger, differences of opinion as to the location of its route became more marked. Sentiment swung, with changing Congressional majorities, from the northern route proposed by Whitney, to a central route, a southern route, or a compromise by the adoption of three routes. A historian of this period has said that it is difficult to determine whether the Pacific railroad project came nearer being talked to death by its friends than by its enemies. For more than a decade the controversy raged, and was not finally settled until the secession of the southern states gave the proponents of a central route a clear opportunity for action—and until that same secession had made action imperative.

Lincoln Signs the Railway Act

EVEN with the southern members absent from both houses of Congress, there was much wrangling over the terms of the legislation which led to the building of the first railroad to the Pacific, and it was not until July 1, 1862, that the Pacific Railway Act became a law by the signature of President Lincoln.

This act provided that the road was to run from Omaha to San Francisco.

The eastern portion of the line was to be built by a newly created corporation—the first since the Second United States Bank to receive its charter from the federal government. This was the Union Pacific Railroad Company. The section which it was to build extended from Omaha to the California state line. From this point westward to San Francisco, construction was to be undertaken by the Central Pacific Railroad Company, a California corporation. A government subsidy was offered in the form of a land grant—reminiscent of the Whitney plan—and a loan of the credit of the United States. The latter was necessary because the land grant could not be turned into immediate cash, for sales must await settlement, and settlement would be slow until the railroad was built.

With the details of how the building of the Union Pacific was financed, we are not, in the present discussion, greatly concerned. Time and space do not permit, and inclination does not prompt, an extended analysis of the Credit Mobilier, the operations of which were so intricate, to say the least, that eventually they were the subject of two Congressional investigations and became an issue of at least one Presidential campaign. The picturesque "Jim" Fiske and the not less striking figure of Jay Gould, who played a part in the history of the Union Pacific that was by no means inconsiderable, must be left for treatment elsewhere.

The Task Completed

SUFFICE it to say that, despite financial handicaps which were at times not less serious than those imposed by the nature of the country through which the road was constructed, the project was eventually completed. But progress was discouragingly slow. The Central Pacific began to build eastward from Sacramento in 1864, but by the early part of 1866 had laid down only fifty-six miles of track. The Union Pacific, building westward from Omaha, had completed only its first forty miles of track during the same period. Before these two companies had finished their work, the Central Pacific had constructed 689 miles of road and the Union Pacific 1,086 miles. On the tenth of May, 1869, engines of the two companies met at Promontory Point, Utah, and the picturesque ceremony of "driving the last spike" bore witness that America's first transcontinental railroad was an accomplished fact.

IN dealing with the transcontinental railway as an instrumentality of communication, it is natural to think of it, first of all, as a carrier of mails. The report of the Postmaster General for 1869 shows that a contract with Wells, Fargo & Company for the transportation of the mails between the western terminus of the Union Pacific and the eastern terminus of the Central Pacific came to an end, under its own provisions, when the two railroads met on May 9, and were reported to be ready to carry the mails on the following day. It would appear that the historic ceremony of driving the golden spike was immediately followed by the far more important event of the actual transportation of mails, passengers, and freight over the newly opened line.

In a broader sense of the term, communication may be considered as in-

THE GOLDEN SPIKE IS DRIVEN

That historic ceremony at Promontory Point, Utah, has been completed, the locomotives from East and West have approached each other, and notables and spectators pose for their photograph. (From the Union Pacific collection)

cluding not only the carrying of messages, but the carrying of passengers, freight, express, etc.—the meeting of any needs, in other words, which arise out of the fact that two or more persons, who have relations with each other, are separated by the barriers of time and distance. Measured in terms of volume and of receipts from payments for their transportation, mails play an almost insignificant part in the service performed by such transportation instrumentalities as railways.

This fact, which still holds true in spite of the enormous increase in the amount of postal matter handled, is well illustrated by a summary of earnings of the Union Pacific for 1870, the first full year of its operation. In round numbers, these were: Commercial passenger, $3,528,000; Government passenger, $280,000; Commercial freight, $2,360,000; Government freight, $263,000; Company freight, $425,000; Express, $281,000; U. S. mail, $242,000. Thus it appears that, measured in terms of earnings, the transportation of messages was the least important function of the first coast-to-coast railway.

The Importance of Communication

PERHAPS this would be as good a place as any to point out, however, that while one of the functions of

transportation instrumentalities is to enable people to travel, another is to make it possible for them to remain at home. This somewhat paradoxical situation arises from the fact that the letters carried by these means of transport are, virtually, substitutes for the persons who send them, and make the journey in their stead. So also with freight and express—the mere fact that carloads of oranges may be shipped from a distant state to New York makes it possible for millions of people in the latter city to experience the delight of tasting these fruits without journeying to their point of origin to do so.

It must be remembered, however, that communication, in its narrower sense, has a direct and significant bearing on the importance of the other services performed by the transportation facilities. Most passengers who travel across the continent by rail do so in accordance with arrangements they have made by mail, telegraph, or telephone. Practically every pound of freight or express that is shipped from coast to coast has been ordered by one of these means of transmitting messages.

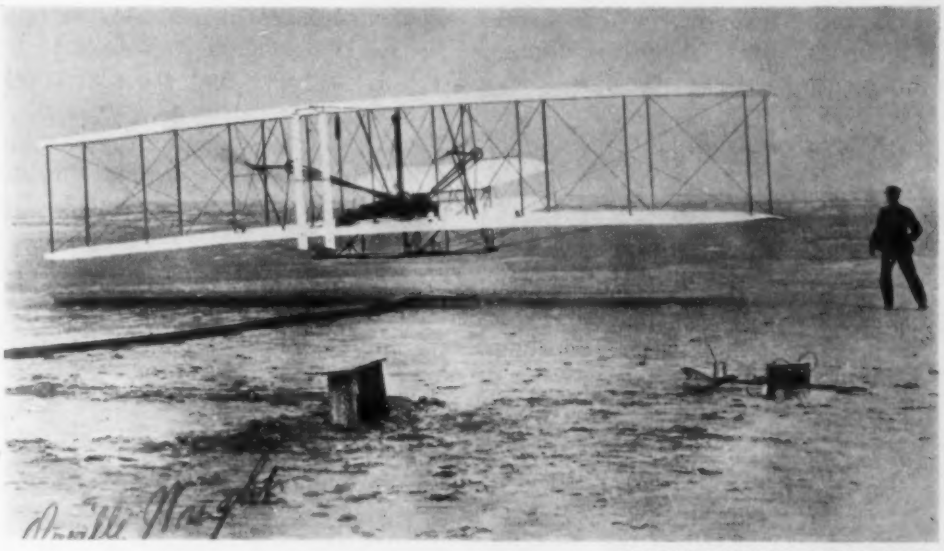
Because it met, for the time being, a national need which was, as has been indicated, a many-sided need, the Union Pacific prospered. But because this need was to grow too great and too urgent to be met by a single railroad, other lines to the Pacific were soon to be built—and, in course of time, a still swifter method of transportation was to be developed.

The Development of Aviation

AT exactly the time when gangs of coolies and Irish immigrants were laying the tracks for the first railroad to cross the western plains, two Germans, Otto and Langen, were experimenting with a contrivance which, when they had finally brought it to patentable form, became known as the internal combustion engine. Out of their pioneer work grew the automobile (with which, in our consideration of transcontinental communication, we are not greatly concerned) and the motive power which makes the modern airplane possible. As inevitable as was the fact that the railway should supplement, and later supplant, the post rider and the mail stage was it that the airplane should supplement the Railway Mail Service —though it has not supplanted it and probably never will. To this latest form of transportation, as an instrumentality of communication, let us briefly turn our attention.

The history of air transport, as a factor in communication in America, may be thought of as beginning in 1793, when Jean Pierre Blanchard, a French aeronaut, ascended in a balloon from Philadelphia, carrying with him a letter from President Washington calling upon all citizens to "receive and aid him with that humanity and good will which may render honor to their country and justice to an individual so distinguished by his efforts to establish and advance an art, in order to make it useful to mankind in general." The balloon remained aloft for forty-five minutes and descended at Woodbury, N. J., fifteen miles from its starting point.

Because of limitations inherent in its nature, the balloon never attained, as a means of communication, any degree of capability of being made "use-



CURTISS-WRIGHT CORPORATION

AN EPOCHAL EVENT

The Wright brothers' first flight, near Kitty Hawk, N. C., on December 17, 1903, lasted 12 seconds and covered 120 feet. In this picture, the only one taken of this momentous happening, Orville Wright lies prone at the controls and Wilbur Wright, running beside the plane, has released his hold on the wing as the craft leaves the ground. Note the autograph of Orville Wright at the lower left

ful to mankind in general." Whatever its form, the lighter-than-air flying machine was destined always to be at the mercy of wind currents—even after it had become a so-called dirigible. It was not until December 17, 1903, when the Wright Brothers lifted their frail craft from the sand dunes at Kitty Hawk, North Carolina, that man's real conquest of the air began.

NEARLY a decade was to elapse after the Wrights' first flight before serious consideration was given in the United States to the use of the airplane for the purpose of transporting regular mail. At an aviation meeting at Nassau Boulevard, Long Island, September 23–30, 1911, mail was carried between a temporary post office on the air field and the post office at Mineola, several miles away. In the same year Calbraith P. Rodgers made the first transcontinental airplane flight, from Sheepshead Bay, New York, to Pasadena, California. The trip took him forty-nine days, from September 17 to November 5, and was made up of a series of short flights, with many stops due to mechanical troubles or weather conditions. Progress in aviation was relatively slow until the use of the airplane for military purposes in the World War gave it great impetus. About this time there arose a demand for the use of this newly developed method of transport as an adjunct to the postal service. The first air mail route in the United States was established on May 15, 1918, between New

York and Washington, with a stop at Philadelphia for the exchange of mails and planes.

Transcontinental Air Mails

SERVICE over this route—admittedly established as an experiment—proved so satisfactory that the Post Office Department began to formulate plans for a coast-to-coast air mail. This service was built up by establishing, in succession, four "legs" of a route eventually connecting New York and San Francisco. The first of these, connecting Cleveland, Ohio, and Chicago, Illinois, with a stop at Bryan, Ohio, was inaugurated on May 15, 1919, exactly a year after the establishment of the New York-Washington route. On July 1 of the same year, New York was connected with Cleveland, with a stop at Bellefonte, Pennsylvania. On May 15, 1920—the second anniversary of the service—the third leg of the transcontinental route, from Chicago to Omaha, Nebraska, via Iowa City, Iowa, was established. Finally, service over the fourth leg, between Omaha and San Francisco, was inaugurated on September 8, 1920. The route passed over North Platte, Nebraska; Cheyenne, Rawlings, and Rock Springs, Wyoming; Salt Lake City, Utah; and Elko and Reno, Nevada.

Records show that the first westbound plane to fly this leg travelled at the average rate of eighty miles an hour and made the trip without a forced landing, either for weather or mechanical trouble. The plane carried 16,000 letters.

This flight, and those which followed for a number of years, were made in planes owned and operated by the Post Office Department. It will be recalled that the transcontinental communication services thus far described, although many of them were the beneficiaries of government aid in the form of mail subsidies or otherwise, were inaugurated and carried on as private enterprises. To this general practice the air mail was an exception. Initially it was a government-operated project. Post office authorities have stated that it was, however, never its intention to operate the service any longer than was necessary to demonstrate the practicability of commercial aviation and thereby induce private enterprise to enter the field and eventually take over the operation of the air mails.

THIS condition was deemed to have been met during the latter part of 1926. Early in 1927 a contract was let, after advertisement for bids, for the Chicago-San Francisco half of the transcontinental route. Under this contract, a company which later became the Boeing Air Transport took over operation of this route on July 1, 1927. The Post Office Department continued operation of the New York-Chicago section of the route until a satisfactory bid had been received from the National Air Transport, Inc. That company took over operation on September 1, 1927.

With the exception of a brief interval, when the service was reorganized in 1934 and the flying of the mails was assigned to pilots of the United States Army, operation of all air mail routes has since then been carried on by private concerns, under government contract.

SCENE OF THE FIRST AIR MAIL EXPERIMENT IN THE UNITED STATES

During an "International Aviation Meet" held at the Nassau Boulevard "aerodrome" on Long Island during September of 1911, regular mail-carrying flights were made to Mineola, L. I., where the mail sacks were "dropped in a field at the feet of the postmaster." (Reproduced from the Scientific American *of October 7, 1911)*

The inauguration of night-flying, made possible by the use of lighted air routes and various forms of radio apparatus; the increase in the length of "haul" that is possible without change of pilots or planes; vast improvement in equipment and personnel—all these and many other factors have contributed toward making the coast-to-coast air mail service what it is today. As of December 15, 1939, schedules issued by the Post Office at New York showed ten air mails a day from that city to various points in California; five to points in Oregon; five to points in the State of Washington. Typical of the time made by these coast-to-coast planes is that of one for which the mail closes at New York at 6 A.M. and reaches San Francisco at 2:40 A.M. the next day. Service from west to east is on approximately the same schedule as from east to west.

RATES for air mail postage over the transcontinental routes have gone through a period of transition. When the air service was first established, between New York and Washington, in 1918, the rate was twenty-four cents an ounce; this was later reduced to sixteen cents; then to six cents; and on July 18, 1919, the extra charge was removed altogether, air mail being carried at the regular domestic rate. In August, 1923, a zone rate was established with a charge of eight cents between New York and Chicago, a like amount between Chicago and Cheyenne, and another eight cents be-

A CURTISS JENNY

Open cockpit airplanes such as this carried the mail two decades ago, during the Post Office Department's establishment and operation of air mail routes

tween Cheyenne and San Francisco. On February 1, 1927, a new rate of ten cents per one-half ounce, regardless of distances, was put into effect, thereby doing away with the complicated zoning system then used on transcontinental and other contract routes. The present rate for each ounce or fraction thereof is six cents to any part of continental United States and Alaska. The rates to outlying islands and possessions vary between ten and fifty cents per one-half ounce or fraction thereof.

Air Passenger Service

THE development of air mail service gave marked impetus to the growth of passenger service as well, since the Act of Congress of February, 1925, empowering the Postmaster General to make contracts with private companies for carrying the mails, had the effect of granting subsidies for the development of both mail and transport service.

Various inter-city air transport lines were established, and it is probable that within a few years after the passage of the Congressional Act referred to above, it was possible to travel by air across the continent by making transfers from one line to another. The next step, taken in 1929, was an arrangement by which passengers were carried across the continent partly by airplane and partly by rail. Thus, passengers were carried from New York to Columbus, Ohio, by rail; from there to Waynoka, Oklahoma, by plane; thence to Clovis, New Mexico, by rail; and from this point to Los Angeles by plane.

About a year later, air passenger service entirely by plane was established between New York and Los Angeles, but an overnight stop was made at Kansas City, this being necessitated because, as yet, little progress had been made in promoting the practicability of night flying. From this point on, however, marked ad-

vances were made in the solution of the problem of providing twenty-four-hour service. The provision of larger flying fields, properly lighted, and the development of radio telephone and other communication services which contributed to the safety of flying in the dark, soon made it possible to inaugurate a service that was, in its main characteristics, like the transcontinental air transport service of today.

On August 1, 1932, United Air Lines inaugurated day-and-night passenger service between New York and San Francisco, with a flying time of twenty-six and three-quarters hours eastward and thirty-one hours westward. On November 5 of the same year, Transcontinental & Western Air, Inc., established a similar service between New York and Los Angeles. The flying time for the initial trips was twenty-four hours and forty-two minutes eastward and twenty-eight hours and forty-three minutes westward. According to a recent table, the quickest flying time for a scheduled flight from New York to San Francisco is seventeen hours and fifty-six minutes; from New York to Los Angeles, fifteen hours and eight minutes.

WITH this brief review of the history of the air mail, our consideration of those instrumentalities of communication which depend on the physical transportation of written messages comes to an end. The third and concluding portion of this study of the place which transcontinental telephony holds in the over-all picture of communication across the American continent will be devoted to those products of man's inventive faculty which, in one form or another, have employed electricity for the transmission of intelligence over distances.

(To be concluded)

FOR THE RECORD

T. K. SMITH ELECTED AN A. T. & T. DIRECTOR

At the meeting of the Board of Directors of the American Telephone and Telegraph Company on October 16, Tom K. Smith was elected to fill the vacancy caused by the death of David F. Houston on September 2. Mr. Smith is President of the Boatmen's National Bank of St. Louis, and has been a Director of the Southwestern Bell Telephone Company. Mr. Houston had been a Director since 1924. He became President of the Bell Telephone Securities Company in 1921, and from 1925 to 1927 was a Vice President of the A. T. and T. Company.

DR. BUCKLEY SUCCEEDS DR. JEWETT AS PRESIDENT OF THE BELL LABORATORIES

On October 1 Dr. F. B. Jewett, Vice President of the American Telephone and Telegraph Company in charge of research, resigned as President of the Bell Telephone Laboratories, becoming Chairman of the Board of Directors. Dr. O. E. Buckley, Executive Vice President of the Laboratories, succeeds Dr. Jewett as President.

There is no change in Dr. Jewett's responsibilities for the general program of research in the Bell System, but the change will increase the time he has available in an advisory capacity to the Government as President of the National Academy of Sciences and as a member of the National Defense Research Committee. Dr. Jewett has been the operating head of the research program of the Bell System for twenty-four years and responsible both for the program and its operation since the retirement in 1930 of John J. Carty, who at that time was Chairman of the Board of the Laboratories.

Dr. Buckley, the new President, joined the staff of the Western Electric Company in 1914, since when he has been intimately associated with telephone research. He became Executive Vice President in 1936, upon the retirement of Mr. E. H. Colpitts.

OPEN DIRECT TELEPHONE CIRCUIT TO SPAIN

Regular telephone service between the United States and Spain, suspended since the outbreak of the Spanish civil war in 1936, was restored on October 22 with the opening of a direct short-wave radio circuit between New York and Madrid. Previously, calls were routed over New York–London radio channels and completed their journey by cable and wire lines. The new channel also becomes the normal route for calls to Portugal, which at present travel via Rome and Berlin. It enables all Bell System and Bell-connected telephones in this country to reach telephone subscribers throughout Spain and Portugal. The radio link is jointly operated by the A. T. & T. Company and the National Telephone Company of Spain, a subsidiary of the International Telephone and Telegraph Corporation, which operates Spain's telephone system.

CONTRIBUTORS TO THIS ISSUE

In 1911, following three years at Lehigh University, Raymond C. Silvers joined the outside plant construction organization of the American Telephone and Telegraph Company. The next six years brought him varied experience in outside plant construction, maintenance, material supply, and engineering, during which time his association also included the Western Union Telegraph Company and the Western Electric Company. From 1917, when the Long Lines Engineering Department of the American Telephone and Telegraph Company was formed, until 1924, he was engaged in the engineering of the toll outside plant. Transferred to the Department of Operation and Engineering of the American Company in 1924, his present responsibilities are the outside plant engineering practices applying to the toll and exchange plant. He is the author of "Some Recent Advances in Rural Construction," which appeared in the Quarterly for October, 1939.

Entering Yale in 1914, Judson S. Bradley left college in 1917 to enlist in the U. S. Army Ambulance Service. Returning from overseas in 1919, he reentered college, and received his B.A. degree in 1920. For the next four years he was assistant editor and managing editor of the *Yale Alumni Weekly*. In 1925 he joined the Publicity Department of the Southern New England Telephone Company, in New Haven, as copy writer, and was subsequently advertising manager until 1928. In that year he was transferred to the Commercial Division of the American Telephone and Telegraph Company, and in 1930 became a member of the staff of the General Information Department. He has contributed several articles to the Quarterly, of which the most recent was "The Bell System Meets Its Greatest Test," in the issue for October, 1938.

Before joining the Bell Telephone Laboratories in 1929, Franklin L. Hunt had been for ten years a member of the staff of the National Bureau of Standards, where he was successively chief of the aeronautic instrument section, assistant chief of the engineering physics division, and engaged in x-ray research. In connection with aircraft instrument development work he spent a year in Europe as special representative of the Bureau of Standards. He had also been assistant manager of engineering and research at the Victor Talking Machine Company. Dr. Hunt received the degrees of S.B. and Ph.D. from Massachusetts Institute of Technology and of A.M. from Harvard, studied at the Universities of Paris, Berlin, and Cambridge, and has taught and lectured at Harvard, M. I. T., and George Washington University. He is a Fellow of a number of scientific societies and the author of papers on various scientific topics. At the Laboratories, Dr. Hunt was for several years in direct charge of work on sound picture recording and reproduction, and since 1935 has been a member of the Bureau of Publication.

Entering the Plant Department of the Bell Telephone Company of Pennsylvania at Philadelphia in 1918, H. Carl Ruth was appointed Supervisor of Supplies in 1926, and Superintendent of Buildings and Supplies in 1927. In 1928 he was transferred to the Diamond State Telephone Company at Wilmington, Delaware, as District Plant Superintendent. In 1930 he joined the American Telephone and Telegraph Company in the Plant Operation Division, where he is

engaged in the development of supply distribution methods and related operations.

RECEIVING the B.A. degree from Lafayette College in 1907, and the LL.B. degree from New York Law School in 1909, ROBERTSON T. BARRETT practiced law until 1918, and for the next three years was engaged in newspaper work. In 1921 he joined the Information Department of the A. T. & T. Company, and since 1936 he has combined his duties in that department with those of Historical Librarian of the A. T. & T. Co. He is editor of the *Telephone Almanac*, and has contributed a number of articles to the QUARTERLY, the most recent being "The Telephone as a Social Force" in the issue for April, 1940.